Global, regional, and national burden of traumatic brain injury and spinal cord injury, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016

GBD 2016 Traumatic Brain Injury and Spinal Cord Injury Collaborators*

Summary

Background Traumatic brain injury (TBI) and spinal cord injury (SCI) are increasingly recognised as global health priorities in view of the preventability of most injuries and the complex and expensive medical care they necessitate. We aimed to measure the incidence, prevalence, and years of life lived with disability (YLDs) for TBI and SCI from all causes of injury in every country, to describe how these measures have changed between 1990 and 2016, and to estimate the proportion of TBI and SCI cases caused by different types of injury.

Methods We used results from the Global Burden of Diseases, Injuries, and Risk Factors (GBD) Study 2016 to measure the global, regional, and national burden of TBI and SCI by age and sex. We measured the incidence and prevalence of all causes of injury requiring medical care in inpatient and outpatient records, literature studies, and survey data. By use of clinical record data, we estimated the proportion of each cause of injury that required medical care that would result in TBI or SCI being considered as the nature of injury. We used literature studies to establish standardised mortality ratios and applied differential equations to convert incidence to prevalence of long-term disability. Finally, we applied GBD disability weights to calculate YLDs. We used a Bayesian meta-regression tool for epidemiological modelling, used cause-specific mortality rates for non-fatal estimation, and adjusted our results for disability experienced with comorbid conditions. We also analysed results on the basis of the Socio-demographic Index, a compound measure of income per capita, education, and fertility.

Findings In 2016, there were 27·08 million (95% uncertainty interval [UI] 24·30–30·30 million) new cases of TBI and 0·93 million (0·78–1·16 million) new cases of SCI, with age-standardised incidence rates of 369 (331–412) per 100 000 population for TBI and 13 (11–16) per 100 000 for SCI. In 2016, the number of prevalent cases of TBI was 55·50 million (53·40–57·62 million) and of SCI was 27·04 million (24·98–30·15 million). From 1990 to 2016, the age-standardised prevalence of TBI increased by 8·4% (95% UI 7·7 to 9·2), whereas that of SCI did not change significantly (–0·2% [–2·1 to 2·7]). Age-standardised incidence rates increased by 3·6% (1·8 to 5·5) for TBI, but did not change significantly for SCI (–3·6% [–7·4 to 4·0]). TBI caused 8·1 million (95% UI 6·0–10·4 million) YLDs and SCI caused 4 million (95% UI 6·0–10·4 million) YLDs in 2016, corresponding to age-standardised rates of 111 (82–141) per 100 000 for TBI and 130 (90–170) per 100 000 for SCI. Falls and road injuries were the leading causes of new cases of TBI and SCI in most regions.

Interpretation TBI and SCI constitute a considerable portion of the global injury burden and are caused primarily by falls and road injuries. The increase in incidence of TBI over time might continue in view of increases in population density, population ageing, and increasing use of motor vehicles, motorcycles, and bicycles. The number of individuals living with SCI is expected to increase in view of population growth, which is concerning because of the specialised care that people with SCI can require. Our study was limited by data sparsity in some regions, and it will be important to invest greater resources in collection of data for TBI and SCI to improve the accuracy of future assessments.

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Evidence before this study

Previous epidemiological studies of the incidence and outcomes of traumatic brain injury (TBI) and spinal cord injury (SCI) have been limited by focusing on certain subpopulations, including only select injuries, or by providing estimates only for areas of the world with accessible data. Previous Global Burden of Diseases, Injuries, and Risk Factors (GBD) studies have reported the burden of injury by cause of injury, such as self-harm, road injuries, and falls, but have not reported results by nature of injury sustained as a result of those causes, including TBI and SCI. To date, no studies have systematically measured the burden of TBI and SCI globally for all countries, ages, and sexes through recent years and from all causes of injury. To identify sources of injury data that could inform an assessment of non-fatal burden from TBI and SCI, we used results from the GBD 2016 injuries estimation process, which included systematic reviews of injury incidence data for all causes of injury that were initially done for GBD 2010 and updated as new data and literature studies became available in GBD 2013, GBD 2015, and GBD 2016. Inclusion criteria for the systematic reviews were representative, population-based surveys; reporting of injuries incidence; and clinical records from general hospitals, outpatient primary care facilities, and health insurance claims when such data were available with injury diagnosis codes. In this study, we updated a previous review of injuries data done for the World Bank that contributed to GBD 2010, GBD 2013, and GBD 2015 by searching the Global Health Data Exchange for surveys, hospital datasets, and literature studies in any language that were tagged as having injury-related data up to Dec 31, 2016.

Added value of this study

In this study, we used for the first time the GBD 2016 framework to report estimates of the global, regional, and national burden in terms of incidence, prevalence, and years of life lived with disability of TBI and SCI for 195 countries and territories. We have provided these estimates globally, by region, and by Socio-demographic Index quintiles in 2016, as well as the percentage change since 1990. We also provide estimates of the proportions of TBI and SCI caused by different causes of injury for each geographical region in 2016. Although epidemiological assessments that focus on particular populations have been done, no other studies of TBI or SCI have provided estimates in this level of detail for all countries derived from a standardised, systematic approach. We were able to measure uncertainty in our estimates by using the uncertainty propagation methods used throughout the GBD study.

Implications of all the available evidence

Our estimates suggest that TBI and SCI are severely disabling injuries. The global burden of TBI increased significantly between 1990 and 2016, whereas that of SCI has not changed significantly over time in terms of age-standardised incidence and prevalence. Age-standardised incidence and prevalence of TBI and SCI were high in central Europe, eastern Europe, and central Asia; the incidence and prevalence of SCI were high in North America and western Europe. Addressing the global burden of these conditions requires improved efforts to decrease the causes of SCI and TBI (eg, fall-prevention strategies, reducing alcohol overuse, and improving road safety, all of which could help to prevent injuries or decrease injury severity) and improved access to, and quality of, medical and social care (which could improve survival and reduce morbidity). People with TBI or SCI can have other medical conditions that require close supervision and might benefit from rehabilitation and medical care to reduce disability. Hence, although injury prevention efforts are key, health-care systems should also anticipate a growing burden from caring for people with TBI and SCI. These conditions could necessitate special focus within health-care systems, because they can be medically complex and burdensome for patients, clinicians, and families. In the future, development of improved methods for surveillance of TBI and SCI will be important, particularly in low-income settings, as will development of methods to identify patients with TBI who do not seek medical care.

such as falls, road injuries, and interpersonal violence. As a result, few comprehensive epidemiological assessments have been done across all sources of injury, despite increasing dialogue about the long-term neuropsychological consequences of concussions in young people and professional athletes playing sports and about the risk of TBI from head trauma in bicycle crashes and other causes of injury. Epidemiological studies that have focused specifically on TBI and SCI without estimation of all potential causes of injury have identified substantial burdens, but are often limited by relying on locations where incidence data were available without adopting modelling strategies for estimation of the burden in locations where data were sparse. Epidemiological assessments have been done in low-income and low-middle-income countries but typically have been limited by poor availability of data. Few studies have reported age-standardised incidence rates, which would enable comparison between countries with different populations, and the studies that have reported such data showed that the incidence rates of TBI and SCI vary substantially between countries. These studies have not measured the relative disability caused by different injuries over time; such data are important because, whereas injuries such as fractures might be disabling only in the short term, conditions such as cognitive impairment from TBI or paraplegia from SCI can leave patients with lifelong health loss. In general, measurement of the burden of TBI and SCI in greater geographical and demographic detail—and over time—is of substantial value.

The Global Burden of Diseases, Injuries, and Risk Factors (GBD) study is the product of a global research
### Incidence

|                     | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990-2016 | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990-2016 |
|---------------------|-------------|------------------------------------------|------------------------------------------------------|-------------|------------------------------------------|------------------------------------------------------|
| **Global**          |             |                                          |                                                      |             |                                          |                                                      |
| High SDI            | 3682268     | (3112645 to 4194060)                     | -9.4 (-12.2 to -6.2)                                  | 8463137     | (8121936 to 8818355)                     | -7.9 (-8.7 to -7.1)                                   |
| High-middle SDI     | 5550132     | (4977725 to 6205225)                     | -10.7 (-13.3 to -8.4)                                 | 13458443    | (12951657 to 13937352)                   | -5.4 (-6.3 to -4.5)                                   |
| Middle SDI          | 7779905     | (6580600 to 8046104)                     | 25.8 (18.8 to 24.9)                                   | 16745178    | (16127549 to 17364525)                   | 32.6 (31.0 to 33.9)                                   |
| Low-middle SDI      | 8074189     | (7244952 to 8969510)                     | 11.1 (7.6 to 16.5)                                    | 13224272    | (12971979 to 14124365)                   | 18.7 (17.0 to 20.0)                                   |
| Low SDI             | 2607230     | (2391622 to 299764)                     | -9.3 (-14.7 to -6.0)                                  | 3306690     | (3308858 to 3760344)                     | 3.3 (1.9 to 4.8)                                      |
| **High income**     | 3274760     | (2736209 to 3975372)                     | -9.6 (-13.0 to -6.1)                                  | 7330041     | (7013363 to 7655518)                     | -10.2 (-11.0 to -9.2)                                 |
| High-income North America | 1221494 | (1019814 to 1475250)                     | -0.4 (-8.8 to 1.2)                                   | 2603351     | (2488042 to 2726560)                     | -6.3 (-7.9 to -4.6)                                   |
| Canada              | 110332      | (92166 to 133581)                       | -10.4 (-15.2 to -6.0)                                 | 253144      | (241660 to 265695)                       | -11.2 (-12.9 to -9.2)                                 |
| Greenland           | 161         | (131 to 197)                            | -19.0 (-21.2 to -16.5)                                | 281         | (269 to 296)                            | -14.6 (-15.9 to -13.2)                                |
| USA                 | 1110578     | (927814 to 1340515)                     | -3.3 (-8.2 to 2.5)                                    | 2349017     | (2244952 to 2461041)                     | -5.7 (-7.5 to -3.9)                                   |
| Australasia         | 78554       | (65710 to 93741)                       | -13.0 (-18.6 to -7.3)                                 | 178663      | (170767 to 187588)                       | -14.1 (-15.6 to -12.2)                                |
| Australia           | 66020       | (55309 to 78895)                       | -12.1 (-17.8 to -6.3)                                 | 150213      | (143534 to 157799)                       | -13.3 (-14.9 to -11.3)                                |
| New Zealand         | 12555       | (10260 to 14974)                       | -7.1 (-12.2 to -11.1)                                 | 28450       | (27152 to 29828)                        | -8.1 (-10.2 to -6.1)                                  |
| High-income Asia Pacific | 5635238 | (471687 to 681672)                     | -16.9 (-20.6 to -13.1)                                | 1256353     | (1202704 to 1303875)                     | -14.8 (-16.1 to -15.5)                                |
| Brunei              | 1355        | (1036 to 1819)                         | -20.7 (-24.6 to -16.6)                                | 2708        | (2654 to 2857)                          | -21.3 (-22.7 to -19.9)                                 |
| Japan               | 382954      | (291779 to 476002)                     | -5.5 (-9.9 to -11.2)                                  | 891110      | (854680 to 928073)                       | -14.2 (-15.8 to -12.4)                                 |
| Singapore           | 11193       | (93428 to 13739)                       | -4.4 (-10.0 to 0.6)                                   | 234309      | (223655 to 25421)                       | -0.8 (-3.0 to 1.5)                                     |
| South Korea         | 167856      | (131874 to 199372)                     | -19.4 (-23.3 to -14.7)                                | 33225       | (323467 to 352938)                       | -18.4 (-20.1 to -17.0)                                 |
| Western Europe      | 1262700     | (1042418 to 1546907)                   | -13.4 (-17.2 to -9.7)                                 | 3021435     | (2880245 to 3154517)                     | -12.8 (-13.8 to -11.7)                                 |
| Andorra             | 126         | (104 to 292)                           | 4.1 (0.8 to 7.5)                                      | 582         | (554 to 611)                            | 6.2 (4.7 to 7.7)                                      |
| Austria             | 28225       | (23166 to 35170)                       | -19.9 (-24.2 to -14.8)                                | 66670       | (63606 to 69564)                        | -17.7 (-19.4 to -16.2)                                 |
| Belgium             | 41216       | (33848 to 51024)                       | -6.8 (-13.0 to -0.6)                                  | 90487       | (86268 to 94369)                        | -10.1 (-11.7 to -8.1)                                  |
| Cyprus              | 2959        | (2503 to 3516)                        | -10.0 (-14.2 to -5.6)                                 | 6605       | (6280 to 6947)                          | -9.0 (-10.3 to -7.6)                                   |
| Denmark             | 17302       | (14208 to 21444)                       | -14.9 (-19.7 to -10.0)                                | 39756       | (37914 to 41590)                        | -12.5 (-14.0 to -11.0)                                 |

(Table 1 continues on next page)
| Incidence | Prevalence |
|-----------|------------|
|           | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990-2016 | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990-2016 |
| (Continued from previous page) |
| Finland  | 20009 (16226 to 25470) | 344 (284 to 420) | -5.5 (-10.4 to -0.8) | 44066 (40212 to 46103) | 609 (579 to 637) | -4.5 (-6.3 to -2.8) |
| France   | 209986 (170948 to 261143) | 307 (255 to 372) | -19.9 (-24.5 to -15.3) | 466818 (442758 to 488496) | 564 (535 to 593) | -19.8 (-21.4 to -18.1) |
| Germany  | 23643 (192862 to 295657) | 288 (239 to 346) | -12.8 (-18.4 to -7.7) | 59273 (564640 to 619584) | 535 (508 to 562) | -12.6 (-14.2 to -11.1) |
| Greece   | 33459 (27874 to 39411) | 321 (271 to 382) | -9.7 (-14.8 to -4.8) | 89972 | 627 (594 to 660) | -7.9 (-9.2 to -6.4) |
| Iceland  | 926 (766 to 1120) | 282 (232 to 329) | -7.5 (-13.1 to -2.8) | 2021 (19355 to 21100) | 532 (506 to 557) | -7.1 (-8.3 to -5.3) |
| Ireland  | 12298 (10956 to 16111) | 297 (246 to 356) | -6.0 (-11.1 to -0.6) | 28873 (27464 to 30268) | 550 (523 to 578) | -6.5 (-8.1 to -4.9) |
| Israel   | 22803 | 278 | -4.5 (-11.5 to -1.3) | 45734 | 556 (521 to 605) | 4.0 (1.0 to 8.4) |
| Italy    | 191527 (158858 to 231854) | 315 (263 to 377) | -11.7 (-15.7 to -7.3) | 491141 | 596 (566 to 626) | -10.2 (-11.7 to -8.7) |
| Luxembourg | 1771 (1461 to 2157) | 289 (232 to 332) | -26.5 (-31.5 to -21.9) | 3980 (3783 to 4188) | 583 (535 to 591) | -25.7 (-27.1 to -24.3) |
| Malta     | 1170 (965 to 1445) | 315 (240 to 352) | -8.9 (-12.4 to -5.1) | 2870 | 539 (514 to 566) | -5.7 (-7.1 to -4.4) |
| Netherlands | 46656 (38792 to 56158) | 275 (223 to 327) | 0.0 | 112886 | 523 (499 to 549) | 1.2 (-0.8 to 3.1) |
| Norway   | 15956 (13059 to 19836) | 298 (246 to 363) | -5.5 (-10.5 to 0.9) | 34915 (33251 to 36587) | 547 (519 to 574) | -4.3 (-5.5 to -2.5) |
| Portugal | 28078 | 267 | -29.3 (-34.6 to -24.6) | 70982 | 504 (480 to 527) | -28.5 (-30.3 to -26.6) |
| Spain    | 128447 | 284 (237 to 339) | -16.4 (-21.3 to -11.4) | 328217 | 543 (515 to 569) | -16.5 (-18.0 to -14.6) |
| Sweden   | 28106 (20808 to 34819) | 282 (234 to 347) | -4.6 (-9.0 to -0.1) | 63463 (60718 to 66626) | 512 (488 to 536) | -5.9 (-7.6 to -4.2) |
| Switzerland | 25123 (20227 to 31494) | 284 (233 to 343) | -29.1 (-33.8 to -24.9) | 54812 | 499 (476 to 520) | -29.4 (-30.9 to -27.9) |
| UK       | 168579 | 260 (215 to 316) | -5.9 (-9.9 to -2.0) | 382133 | 478 (454 to 499) | -6.4 (-7.5 to -5.3) |
| Southern Latin America | 148473 (124980 to 179106) | 225 (190 to 271) | 11.7 (8.7 to 14.8) | 270229 | 392 (376 to 409) | 151 (139 to 165) |
| Argentina | 100117 (84740 to 120244) | 128 (192 to 273) | 14.0 (9.8 to 18.2) | 179755 | 401 (384 to 418) | 18.0 (16.4 to 19.7) |
| Chile    | 30688 (23880 to 47814) | 214 (178 to 257) | 4.4 (1.1 to 7.7) | 74082 | 368 (352 to 384) | 8.0 (6.3 to 9.5) |
| Uruguay  | 8662 | 244 (205 to 294) | 13.8 (9.4 to 18.3) | 16562 | 424 (406 to 443) | 17.0 (15.2 to 19.0) |
| Central Europe, eastern Europe, and central Asia | 3174597 (2813645 to 3622489) | 740 (657 to 844) | -4.2 (-6.3 to -2.2) | 7505017 (7239950 to 7872428) | 1539 (1464 to 1614) | -0.6 (-1.5 to 0.6) |
| Eastern Europe | 1679786 (1495412 to 1908308) | 772 (688 to 876) | -2.4 (-5.2 to 0.3) | 3987022 (3796684 to 4175331) | 1546 (1472 to 1623) | -1.5 (-3.0 to 0.2) |
| Belarus  | 85268 (74665 to 98805) | 853 (749 to 979) | 15.8 (11.5 to 20.3) | 203206 | 1724 (1632 to 1815) | 15.2 (12.9 to 17.9) |
| Estonia  | 9843 (8613 to 11372) | 722 (635 to 827) | -20.2 (-24.0 to -16.0) | 25698 | 1529 (1445 to 1622) | -14.1 (-16.2 to -11.8) |
| Latvia   | 15151 (13648 to 17822) | 743 (654 to 851) | -22.6 (-26.0 to -18.8) | 38996 | 1519 (1436 to 1601) | -18.4 (-20.2 to -16.6) |
| Lithuania | 26381 (23106 to 30541) | 845 (741 to 972) | -5.5 (-9.4 to -2.3) | 64728 | 1704 (1618 to 1800) | -3.8 (-5.7 to -1.9) |

(Table 1 continues on next page)
## Incidence

| Country          | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 |
|------------------|-------------|----------------------------------------|------------------------------------------------------|
| Moldova          | 25,099      | (22,243 to 28,672)                     | -17.6 (-21.2 to -14.0)                               |
| Russia           | 1,202,502   | (1,074,273 to 1,364,131)               | -1.5 (-4.9 to 2.2)                                  |
| Ukraine          | 315,182     | (278,598 to 360,233)                   | -6.5 (-10.0 to -2.8)                                |
| **Central Europe** | **1,055,830** | **(916,104 to 1,233,304)**            | **-3.0 (-5.9 to -0.4)**                             |
| Albania          | 19,366      | 662                                    | 10.1 (6.5 to 12.9)                                  |
| Bosnia and Herzegovina | 25,864 | (22,252 to 29,894)                     | 42.8 (37.9 to 46.7)                                 |
| Bulgaria         | 57,125      | 776                                    | -5.3 (-9.4 to -3.3)                                 |
| Croatia          | 39,226      | 801                                    | -3.1 (-8.3 to 2.5)                                  |
| Czech Republic   | 115,120     | 1022                                   | -5.3 (-9.8 to -0.3)                                 |
| Hungary          | 96,761      | 865                                    | -19.0 (-23.3 to -14.7)                              |
| Macedonia        | 14,795      | 714                                    | 16.0 (12.3 to 20.0)                                 |
| Montenegro       | 49,765      | 785                                    | 8.5 (5.3 to 11.7)                                   |
| Poland           | 370,019     | 893                                    | 1.0 (-3.6 to 5.2)                                   |
| Romania          | 169,215     | 834                                    | -7.9 (-12.5 to -3.4)                                |
| Serbia           | 65,967      | 733                                    | 13.4 (10.0 to 16.7)                                 |
| Slovakia         | 51,215      | 889                                    | -9.9 (-13.3 to -6.0)                                |
| Slovenia         | 26,182      | 1092                                   | -3.8 (-9.3 to 3.1)                                  |
| **Central Asia** | **439,881** | **(389,647 to 498,547)**              | **0.1 (-2.3 to 2.4)**                               |
| Armenia          | 14,129      | 474                                    | -12.4 (-16.0 to -8.6)                               |
| Azerbaijan       | 45,533      | 465                                    | -3.4 (-6.9 to 0.1)                                  |
| Georgia          | 20,209      | 496                                    | -4.6 (-8.2 to -1.3)                                 |
| Kazakhstan       | 108,784     | 609                                    | 9.8 (5.7 to 14.2)                                   |
| Kyrgyzstan       | 28,144      | 470                                    | -3.4 (-16.7 to -9.6)                                |
| Mongolia         | 19,388      | 513                                    | -33.3 (43.5 to 58.0)                                |
| Tajikistan       | 35,891      | 417                                    | -16.5 (-16.9 to -9.8)                               |
| Turkmenistan     | 24,881      | 448                                    | -0.2 (-1.7 to 0.6)                                  |
| Uzbekistan       | 141,821     | 459                                    | 4.0 (0.1 to 7.5)                                    |

### Prevalence

| Country          | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 |
|------------------|-------------|----------------------------------------|------------------------------------------------------|
| Moldova          | 58,867      | (55,622 to 62,361)                     | -14.2 (-16.4 to -12.0)                               |
| Russia           | 2,810,261   | (2,678,210 to 2,939,902)               | -0.6 (-2.5 to 1.6)                                  |
| Ukraine          | 785,255     | (745,321 to 824,796)                   | -6.1 (-8.1 to -4.1)                                  |
| **Central Europe** | **2,649,259** | **(2,512,485 to 2,792,424)**          | **4.4 (3.3 to 5.5)**                                 |
| Albania          | 48,963      | (46,227 to 51,786)                     | 12.6 (9.7 to 16.1)                                  |
| Bosnia and Herzegovina | 76,637 | (71,724 to 81,170)                     | 16.0 (14.9 to 17.1)                                 |
| Bulgaria         | 157,661     | (149,402 to 165,850)                   | 16.3 (-0.8 to 6.0)                                  |
| Croatia          | 92,177      | (87,994 to 96,575)                     | -18 (-3.8 to 0.6)                                   |
| Czech Republic   | 297,221     | (281,750 to 314,421)                   | 21.7 (20.5 to 23.9)                                 |
| Hungary          | 221,514     | (209,003 to 234,108)                   | 21.6 (17.0 to 26.3)                                 |
| Macedonia        | 37,393      | (35,009 to 39,447)                     | 18 (15.2 to 21.3)                                   |
| Montenegro       | 12,611      | (11,930 to 13,318)                     | 11.5 (9.3 to 13.9)                                  |
| Poland           | 908,548     | (860,062 to 960,247)                   | 18.6 (17.5 to 19.6)                                 |
| Romania          | 434,844     | (411,374 to 458,018)                   | 17.5 (16.5 to 18.4)                                 |
| Serbia           | 174,644     | (164,893 to 184,515)                   | 16.0 (15.1 to 17.0)                                 |
| Slovakia         | 123,805     | (117,261 to 130,731)                   | -2.0 (-3.9 to 0.4)                                  |
| Slovenia         | 63,660      | (60,064 to 67,002)                     | 3.2 (1.3 to 5.5)                                    |
| **Central Asia** | **868,726** | **(823,691 to 916,878)**              | **1.9 (0.7 to 3.2)**                                |
| Armenia          | 39,865      | (36,019 to 45,144)                     | -13 (-17.4 to -9.4)                                 |
| Azerbaijan       | 101,481     | (95,966 to 107,296)                    | -1.6 (-0.9 to 4.5)                                  |
| Georgia          | 48,707      | (46,711 to 51,143)                     | -3.0 (-5.6 to -0.1)                                 |
| Kazakhstan       | 217,996     | (206,518 to 229,023)                   | -11.3 (8.8 to 13.9)                                 |
| Kyrgyzstan       | 51,346      | (48,550 to 54,313)                     | -9.6 (-12.0 to -7.2)                                |
| Mongolia         | 34,544      | (32,803 to 36,466)                     | -12.5 (10.0 to -7.0)                                |
| Tajikistan       | 62,825      | (58,266 to 66,604)                     | -6.9 (-10.1 to -2.2)                                |
| Turkmenistan     | 46,815      | (44,152 to 49,691)                     | 3.6 (1.0 to 5.9)                                    |
| Uzbekistan       | 265,697     | (251,467 to 282,482)                   | 5.4 (3.0 to 7.9)                                    |

(Continued from previous page)
| Country                  | Incidence 2016 counts | 2015 age-standardised rates (per 100,000) | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 | Prevalence 2016 counts | 2015 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 |
|--------------------------|------------------------|------------------------------------------|------------------------------------------|-----------------------------------------------------|------------------------|------------------------------------------|-----------------------------------------------------|
| Latin America and Caribbean | 13845785 (1655712 to 2074570) | 330 (296 to 372) | 1.1 (-0.9 to 3.3) | 3712361 (3549097 to 3887453) | 681 (650 to 710) | 3.6 (2.2 to 4.9) |
| **Central America**       |                        |                                    |                                         |                                                     |                        |                                         |                                                     |
| Colombia                  | 716600 (642948 to 806959) | 293 (263 to 330) | -9.5 (-11.6 to -7.6) | 1412146 (1349779 to 1474463) | 609 (584 to 635) | -5.0 (-5.9 to -3.9) |
| Costa Rica                | 15073                  | 116 (92 to 140) | 18.3 (13.8 to 23.1) | 33681 (31463 to 35326) | 677 (643 to 710) | 4.8 (31.2 to 28.3) |
| El Salvador               | 19120                  | 117 (92 to 142) | 1.0 (-7.3 to 7.0) | 37724 (35244 to 40291) | 660 (622 to 705) | 5.5 (-0.5 to 9.6) |
| Guatemala                 | 45333                  | 301 (269 to 341) | 14.2 (6.5 to 19.9) | 73308 (69788 to 77512) | 593 (568 to 620) | 19.1 (15.0 to 24.4) |
| Honduras                  | 20923                  | 279 (246 to 317) | 30.4 (25.3 to 36.2) | 65785 (628280 to 687951) | 565 (532 to 610) | 33.1 (26.4 to 42.1) |
| Mexico                    | 341669                 | 279 (249 to 315) | -19.7 (-21.8 to -17.7) | 29229 (27332 to 31424) | 564 (531 to 609) | -0.0 (-5.3 to 4.5) |
| Nicaragua                 | 15254                  | 263 (233 to 299) | 4.8 (1.1 to 8.7) | 25833 (24514 to 27043) | 683 (649 to 715) | 24.0 (20.1 to 27.1) |
| Panama                    | 12357                  | 315 (281 to 354) | 19.1 (15.2 to 23.4) | 215699 (205565 to 225352) | 742 (709 to 775) | 19.6 (16.8 to 22.5) |
| Venezuela                 | 107073                 | 348 (312 to 390) | 14.0 (9.4 to 18.7) | 338665 (320850 to 354351) | 640 (610 to 670) | 12.1 (10.2 to 14.0) |
| Andean Latin America      | 175372                 | 303 (271 to 340) | 7.9 (4.7 to 11.2) | 55875 (53030 to 58747) | 608 (579 to 638) | 2.6 (0.2 to 5.1) |
| Bolivia                   | 31106                  | 294 (262 to 329) | -4.0 (-7.0 to –1.2) | 101533 (96588 to 106302) | 696 (663 to 728) | 11.8 (9.3 to 14.3) |
| Ecuador                   | 55753                  | 350 (310 to 398) | 16.5 (9.0 to 26.0) | 180637 (170825 to 189957) | 682 (650 to 652) | 15.1 (11.8 to 18.3) |
| Peru                      | 58913                  | 282 (252 to 316) | 6.8 (2.3 to 11.4) | 322991 (292210 to 359914) | 706 (640 to 788) | 29.9 (20.2 to 44.6) |
| Peru                      | 78933                  | 98 (96 to 100) | 7.9 (6.0 to 9.8) | 101533 (96588 to 106302) | 696 (663 to 728) | 11.8 (9.3 to 14.3) |
| Caribbean                 | 145899                 | 320 (285 to 360) | 21.1 (12.9 to 24.5) | 596 (566 to 625) | 640 (607 to 671) | 18.5 (15.6 to 21.4) |
| Antigua and Barbuda       | 263                    | 291 (259 to 326) | 15.4 (12.3 to 18.8) | 2720 (25911 to 28431) | 660 (629 to 690) | 11.2 (8.6 to 14.5) |
| The Bahamas               | 1222                   | 314 (281 to 352) | 6.3 (2.9 to 9.8) | 1899 (189208 to 2084) | 695 (659 to 628) | 31.7 (28.6 to 35.3) |
| Barbados                  | 782                    | 275 (246 to 309) | 19.2 (16.2 to 22.5) | 31873 (30675 to 32795) | 659 (629 to 685) | 50 (24.7 to 7.7) |
| Belize                    | 1148                   | 321 (289 to 358) | 32.3 (26.4 to 37.1) | 490539 (490539 to 539) | 719 (684 to 752) | 5.0 (2.4 to 7.7) |
| Bermuda                   | 216                    | 322 (286 to 361) | -4.0 (-7.5 to –0.2) | 91245 (91013 to 339) | 680 (646 to 719) | 10.6 (7.6 to 13.9) |
| Cuba                      | 41964                  | 338 (296 to 387) | 12.5 (8.0 to 17.7) | 458 (434 to 481) | 610 (578 to 641) | 35.5 (31.0 to 40.0) |
| Dominica                  | 210                    | 284 (254 to 319) | 32.7 (29.1 to 36.5) | 65036 (61668 to 68195) | 678 (645 to 709) | 34.1 (30.0 to 37.7) |
| Dominican Republic        | 32270                  | 308 (277 to 343) | 27.7 (23.2 to 36.2) | 476 (409 to 476) | 645 (612 to 674) | 31.5 (28.5 to 34.6) |
| Grenada                   | 333                    | 317 (283 to 356) | 29.8 (26.2 to 33.5) | 4176 (3972 to 4380) | 589 (561 to 616) | 19.1 (16.5 to 22.0) |
| Guyana                    | 2297                   | 307 (276 to 344) | 15.4 (11.7 to 19.3) | 7467 (748 to 10877) | 748 (730 to 1087) | 69.6 (60.6 to 78.6) |
| Haiti                     | 31804                  | 289 (255 to 327) | 20.1 (12.3 to 31.0) | 48208 (48208 to 108152) | 748 (730 to 1087) | 69.6 (60.6 to 78.6) |

(Table 1 continues on next page)
### Incidence

| Country                        | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 |
|-------------------------------|-------------|------------------------------------------|-----------------------------------------------------|
| Jamaica                       | 7721        | (6895 to 8611)                           | 38.9 (35.5 to 42.7)                                  |
| Puerto Rico                   | 13,213      | (11,678 to 15,024)                       | 21.8 (17.1 to 27.0)                                  |
| Saint Lucia                   | 526         | (463 to 592)                             | 20.1 (16.8 to 23.4)                                  |
| Saint Vincent and the Grenadines | 342         | (305 to 387)                             | 29.1 (25.3 to 32.8)                                  |
| Suriname                      | 1684        | (1511 to 1885)                           | 26.1 (22.2 to 30.2)                                  |
| Trinidad and Tobago           | 8,111       | (6,884 to 4,589)                         | 24.9 (20.7 to 29.9)                                  |
| Virgin Islands                | 343         | (306 to 389)                             | 15.2 (11.6 to 18.8)                                  |
| Tropical Latin America        | 807,914     | (720,908 to 913,966)                     | 6.2 (3.0 to 9.8)                                     |
| Brazil                        | 786,433     | (701,498 to 889,704)                     | 5.6 (2.4 to 9.2)                                     |
| Paraguay                      | 21,481      | (18,974 to 24,600)                       | 36.9 (32.6 to 41.7)                                  |
| China                         | 4,481,454   | (4,033,188 to 4,943,337)                 | 33.3 (28.5 to 38.3)                                  |
| North Korea                   | 717,121     | (643,853 to 79,836)                      | 54.8 (49.9 to 63.1)                                  |
| Taiwan (province of China)    | 70,088      | (63,129 to 77,594)                       | 26.2 (21.3 to 31.9)                                  |
| Southeast Asia                | 1,843,182   | (1,667,659 to 2,039,489)                 | 27.1 (20.9 to 32.0)                                  |
| Cambodia                      | 41,142      | (37,163 to 45,610)                       | 25.3 (20.8 to 30.8)                                  |
| Indonesia                     | 672,105     | (605,726 to 743,145)                     | 25.2 (21.4 to 29.1)                                  |
| Laos                          | 1,757       | (1,603 to 1,916)                         | 17.7 (17.0 to 18.4)                                  |
| Malaysia                      | 100,399     | (90,368 to 111,622)                      | 36.5 (32.2 to 41.5)                                  |
| Maldives                      | 772         | (692 to 859)                             | 7.2 (6.3 to 10.5)                                    |
| Mauritius                     | 337         | (304 to 372)                             | 43.8 (39.1 to 48.6)                                  |
| Myanmar                       | 13,998      | (12,272 to 14,898)                       | 43.3 (38.4 to 48.5)                                  |
| Philippines                   | 205,035     | (192,711 to 218,356)                     | 28.7 (21.0 to 38.3)                                  |
| Sri Lanka                     | 63,643      | (57,818 to 70,087)                       | 23.4 (~9.2 to 0.2)                                   |
| Seychelles                    | 306         | (278 to 339)                             | 37.7 (33.4 to 42.4)                                  |

### Prevalence

| Country                        | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 |
|-------------------------------|-------------|------------------------------------------|-----------------------------------------------------|
| Jamaica                       | 16,275      | (15,390 to 17,055)                       | 580 (548 to 608)                                     |
| Puerto Rico                   | 31,248      | (29,568 to 32,767)                       | 731 (690 to 766)                                     |
| Saint Lucia                   | 1,199       | (1,141 to 1,258)                         | 632 (602 to 663)                                     |
| Saint Vincent and the Grenadines | 698         | (661 to 731)                             | 639 (606 to 668)                                     |
| Suriname                      | 3,444       | (3,184 to 3,595)                         | 652 (623 to 680)                                     |
| Trinidad and Tobago           | 9,781       | (9,298 to 10,211)                        | 661 (628 to 691)                                     |
| Virgin Islands                | 834         | (792 to 874)                             | 640 (607 to 672)                                     |
| Tropical Latin America        | 1,648,860   | (1,572,072 to 1,728,016)                 | 763 (728 to 798)                                     |
| Brazil                        | 1,608,456   | (1,533,394 to 1,684,669)                 | 764 (729 to 801)                                     |
| Paraguay                      | 40,404      | (38,084 to 42,978)                       | 692 (655 to 731)                                     |
| China                         | 12,301,082  | (11,843,999 to 12,778,357)               | 739 (712 to 768)                                     |
| North Korea                   | 11,931,974  | (11,487,676 to 12,391,509)               | 742 (715 to 771)                                     |
| Taiwan (province of China)    | 163,389     | (156,812 to 170,561)                     | 590 (566 to 616)                                     |
| Malaysia                      | 205,719     | (197,291 to 213,733)                     | 708 (679 to 732)                                     |
| Southeast Asia                | 4,070,463   | (3,880,114 to 4,273,779)                 | 649 (620 to 680)                                     |
| Cambodia                      | 80,811      | (73,478 to 91,402)                       | 615 (580 to 713)                                     |
| Indonesia                     | 1,453,365   | (1,364,542 to 1,525,952)                 | 595 (559 to 624)                                     |
| Malaysia                      | 219,095     | (209,068 to 229,686)                     | 746 (715 to 781)                                     |
| Maldives                      | 1638        | (1558 to 1716)                           | 505 (483 to 528)                                     |
| Mauritius                     | 8810        | (8434 to 9178)                           | 619 (592 to 646)                                     |
| Myanmar                       | 109,036     | (102,463 to 108,590)                     | 598 (569 to 624)                                     |
| Philippines                   | 52,214      | (49,001 to 55,125)                       | 589 (550 to 621)                                     |
| Sri Lanka                     | 172,628     | (158,213 to 195,277)                     | 794 (727 to 897)                                     |
| Seychelles                    | 694         | (665 to 723)                             | 692 (663 to 720)                                     |

(Continued from previous page)
| Region                      | Incidence | Prevalence |
|-----------------------------|-----------|------------|
|                             | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990-2016 | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990-2016 |
|                             | (Table 1 continues on next page) |           |                                      | (Table 1 continues on next page) |           |                                      |
### Incidence

| Country            | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 |
|--------------------|-------------|-----------------------------------------|------------------------------------------------------|
| Morocco            | 95,064      | (85,330 to 10,706)                     | 0.5 (–2.4 to 3.4)                                    |
| Oman               | 20,498      | (18,259 to 22,719)                     | –5.5 (–9.0 to –2.0)                                  |
| Palestine          | 16,165      | (14,415 to 18,200)                     | –2.8 (–18.9 to 9.5)                                  |
| Qatar              | 11,787      | (10,504 to 13,139)                     | –2.3 (–5.9 to 0.8)                                   |
| Saudi Arabia       | 119,832     | (107,918 to 122,057)                   | –13.5 (–15.2 to –11.5)                               |
| Sudan              | 126,620     | (109,808 to 146,687)                   | 5.7 (–0.6 to 14.5)                                   |
| Syria              | 262,602     | (93,775 to 553,607)                    | 12.2 (90.0 to 0.297)                                 |
| Tunisia            | 34,436      | (30,908 to 38,256)                     | 4.4 (1.4 to 8.2)                                    |
| Turkey             | 248,553     | (222,612 to 277,292)                   | –15.7 (–19.3 to –10.7)                               |
| United Arab Emirates | 46,220  | (41,326 to 51,437)                     | –6.8 (–9.2 to –4.4)                                  |
| Yemen              | 194,741     | (130,687 to 27,397)                    | 9.0 (35.8 to 23.4)                                   |
| South Asia         | 703,930     | (620,303 to 782,364)                   | 4.4 (2.4 to 6.6)                                    |
| Bangladesh         | 540,467     | (485,923 to 599,958)                   | 12.9 (9.6 to 16.3)                                   |
| Bhutan             | 312        | (287,23 to 358,197)                    | 2.1 (–0.5 to 4.7)                                    |
| India              | 5,641,679  | (5,039,029 to 6,262,015)               | 2.3 (0.1 to 4.6)                                     |
| Nepal              | 108,610     | (96,933 to 121,246)                    | 3.9 (–0.9 to 7.3)                                    |
| Pakistan           | 764,843     | (669,513 to 830,822)                   | 19.9 (16.5 to 23.2)                                  |
| Sub-Saharan Africa | 2,956,908   | (2,669,347 to 3,286,997)               | –11.8 (–20.3 to –6.7)                                |
| Southern sub-Saharan Africa | 251,795 | (227,351 to 279,669)                    | –14.4 (–18.0 to –12.0)                               |
| Botswana           | 7864        | (702,287 to 87,875)                    | 1.7 (14.2 to 20.1)                                   |
| eSwatini           | 4735        | (427,530 to 538,075)                   | 1.0 (13.1 to 20.8)                                   |
| Lesotho            | 7016        | (6310 to 7810)                         | 2.5 (24.2 to 24.9)                                   |
| Namibia            | 7400        | (6646 to 8200)                         | –0.2 (–2.8 to 2.4)                                   |
| South Africa       | 185,015     | (167,062 to 205,569)                   | –1.8 (–2.9 to –15.9)                                 |
| Zimbabwe           | 39,766      | (33,598 to 44,047)                     | 2.9 (0.9 to 5.0)                                     |
| Western sub-Saharan Africa | 1,158,340 | (1,040,158 to 1,293,825)               | –2.6 (–4.9 to –0.7)                                  |

### Prevalence

| Country            | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 |
|--------------------|-------------|-----------------------------------------|------------------------------------------------------|
| Morocco            | 222,653     | (203,045 to 224,043)                    | 647 (618 to 680)                                      |
| Oman               | 41,920      | (39,721 to 43,963)                      | 991 (945 to 1036)                                    |
| Palestine          | 25,590      | (22,870 to 30,171)                     | 714 (629 to 875)                                      |
| Qatar              | 24,779      | (23,437 to 26,188)                     | 1155 (1102 to 1210)                                  |
| Saudi Arabia       | 243,943     | (223,202 to 255,668)                   | 855 (821 to 892)                                     |
| Sudan              | 199,299     | (187,481 to 215,246)                   | 679 (605 to 686)                                     |
| Syria              | 149,597     | (140,414 to 181,593)                   | 917 (869 to 1288)                                    |
| Tunisia            | 80,306      | (76,207 to 84,356)                     | 699 (646 to 734)                                     |
| Turkey             | 557,595     | (531,362 to 584,590)                   | 708 (672 to 742)                                     |
| United Arab Emirates | 102,902  | (97,674 to 108,666)                    | 1074 (1028 to 1125)                                  |
| Yemen              | 147,165     | (134,214 to 168,397)                   | 708 (659 to 783)                                     |
| South Asia         | 12,366,812  | (11,871,688 to 12,866,929)             | 828 (794 to 860)                                     |
| Bangladesh         | 580,717     | (535,604 to 1,031,234)                 | 698 (666 to 732)                                     |
| Bhutan             | 5489        | (523,357 to 575,666)                   | 811 (777 to 847)                                     |
| India              | 9,958,355   | (9,558,481 to 10,358,885)              | 846 (811 to 879)                                     |
| Nepal              | 181,820     | (173,484 to 191,390)                   | 751 (717 to 788)                                     |
| Pakistan           | 1,223,430   | (1,174,231 to 1,291,724)               | 803 (769 to 837)                                     |
| Sub-Saharan Africa | 4,182,169   | (3,987,073 to 4,395,220)               | 621 (594 to 649)                                     |
| Southern sub-Saharan Africa | 420,050 | (401,203 to 441,118)                    | 640 (614 to 670)                                     |
| Botswana           | 12,941      | (12,362 to 13,600)                     | 675 (643 to 706)                                     |
| eSwatini           | 6370        | (6053 to 6606)                         | 646 (617 to 675)                                     |
| Lesotho            | 9080        | (8651 to 9546)                         | 529 (507 to 555)                                     |
| Namibia            | 11,413      | (10,830 to 11,979)                     | 578 (551 to 603)                                     |
| South Africa       | 327,583     | (313,064 to 344,174)                   | 680 (652 to 712)                                     |
| Zimbabwe           | 52,663      | (50,084 to 55,611)                     | 471 (452 to 492)                                     |
| Western sub-Saharan Africa | 1,614,512 | (1,537,783 to 1,696,546)               | 597 (572 to 622)                                     |

(Continued from previous page)
### Incidence

| Country                  | 2016 counts (per 100,000) | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990-2016 |
|--------------------------|---------------------------|------------------------------------------|------------------------------------------------------|
| Benin                    | 33 001                    | (30 129 to 37 297)                       | 4 6                                                  |
| Burkina Faso             | 52 314                    | (47 520 to 57 312)                       | -6                                                   |
| Cameroon                 | 70 982                    | (63 788 to 79 440)                       | 3 0                                                  |
| Cape Verde               | 16 542                    | (14 945 to 18 318)                       | 12 2                                                 |
| Chad                     | 47 615                    | (38 159 to 47 636)                       | -7                                                   |
| Côte d'Ivoire            | 27 655                    | (20 780 to 32 511)                       | -3                                                   |
| The Gambia               | 54 711                    | (48 793 to 61 616)                       | -9                                                   |
| Guinea                   | 25 050                    | (21 420 to 39 047)                       | -5                                                   |
| Guinea-Bissau            | 27 175                    | (24 366 to 36 265)                       | -7                                                   |
| Liberia                  | 11 400                    | (9 370 to 14 470)                        | -6 1                                                  |
| Mali                     | 54 493                    | (47 399 to 67 475)                       | -0 0                                                  |
| Mauritania               | 12 094                    | (10 368 to 13 462)                       | -1 1 3                                               |
| Niger                    | 52 541                    | (47 077 to 58 407)                       | -0 6                                                  |
| Nigeria                  | 24 413                    | (20 872 to 28 030)                       | -2 2 4                                               |
| São Tomé and Príncipe    | 670                       | (603 to 748)                             | -0 6                                                  |
| Senegal                  | 44 145                    | (39 611 to 49 997)                       | -0 4                                                  |
| Sierra Leone             | 17 879                    | (16 024 to 19 972)                       | -0 5                                                  |
| Togo                     | 20 024                    | (17 885 to 22 723)                       | -1 9                                                  |
| Eastern sub-Saharan Africa | 1 181 978               | (1 055 453 to 1 317 176)                 | -1 9 1                                               |

### Prevalence

| Country                  | 2016 counts (per 100,000) | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990-2016 |
|--------------------------|---------------------------|------------------------------------------|------------------------------------------------------|
| Benin                    | 47 011                    | (44 631 to 49 362)                       | 6 1                                                  |
| Burkina Faso             | 69 252                    | (65 694 to 72 704)                       | 5 6                                                   |
| Cameroon                 | 95 352                    | (90 299 to 100 578)                      | 5 7                                                   |
| Cape Verde               | 28 101                    | (26 173 to 30 044)                       | 12 2                                                  |
| Chad                     | 54 399                    | (51 499 to 58 350)                       | 5 9                                                   |
| Côte d'Ivoire            | 99 213                    | (93 967 to 104 562)                      | 6 1                                                   |
| The Gambia               | 72 667                    | (68 899 to 76 830)                       | 5 2                                                   |
| Guinea                   | 48 739                    | (46 352 to 51 196)                       | 5 3                                                   |
| Guinea-Bissau            | 77 767                    | (74 000 to 81 273)                       | 6 5                                                   |
| Liberia                  | 77 061                    | (71 937 to 82 191)                       | 6 6                                                   |
| Mali                     | 64 365                    | (60 106 to 68 253)                       | 6 8                                                   |
| Mauritania               | 19 189                    | (18 226 to 20 120)                       | 5 7                                                   |
| Niger                    | 66 915                    | (63 772 to 70 348)                       | 5 6                                                   |
| Nigeria                  | 772 539                   | (73 157 to 81 574)                       | 6 1                                                   |
| São Tomé and Príncipe    | 945                       | (89 972 to 99 992)                       | 6 3                                                   |
| Senegal                  | 61 131                    | (58 199 to 64 314)                       | 6 4                                                   |
| Sierra Leone             | 25 965                    | (24 444 to 28 059)                       | 6 5                                                   |
| Togo                     | 27 967                    | (26 541 to 29 459)                       | 6 6                                                   |
| Eastern sub-Saharan Africa | 1 649 534               | (1 564 002 to 1 748 871)                 | 5 7                                                   |

(Continued from previous page)
Incidence and prevalence of traumatic brain injury in 2016, and percentage change in age-standardised rates by location, 1990–2016

| Location               | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 |
|------------------------|-------------|-----------------------------------------|------------------------------------------------------|-------------|-----------------------------------------|------------------------------------------------------|
| (Continued from previous page) |
| Malawi                 | 45,111      | (40,282 to 50,765)                      | 273                                                  | 13,1       | (15,3 to 10,8)                         | 56,744                                               | (53,648 to 60,217)                                  | 478                                                   | (-12,3 to -7,7)                                    |
| Mozambique             | 86,051      | (77,161 to 95,538)                      | 333                                                  | 1,5         | (11,2 to 9,5)                         | 116,779                                               | (109,146 to 126,995)                                | 629                                                   | 42                                                   |
| Rwanda                 | 33,333      | (29,599 to 37,120)                      | 297                                                  | -35,1       | (-50,5 to -24,7)                     | 63,878                                               | (52,403 to 85,437)                                  | 782                                                   | 270                                                  |
| Somalia                | 38,426      | (32,277 to 50,905)                      | 402                                                  | -11,6       |                                 | 45,828                                               | (42,334 to 51,096)                                  | 645                                                   | 12                                                   |
| South Sudan            | 46,181      | (41,304 to 52,564)                      | 322                                                  | -29,0       |                                 | 63,707                                               | (59,090 to 70,275)                                  | 723                                                   | 11                                                   |
| Tanzania               | 16,321      | (14,860 to 18,579)                      | 322                                                  | -3,1        |                                 | 225,251                                              | (212,622 to 237,194)                                 | 615                                                   | 17                                                   |
| Uganda                 | 116,067     | (103,522 to 129,901)                    | 316                                                  | 0,3         |                                 | 149,404                                              | (139,610 to 161,903)                                 | 609                                                   | 92                                                   |
| Zambia                 | 56,815      | (49,801 to 62,201)                      | 381                                                  | -7,1        |                                 | 69,654                                               | (66,142 to 73,339)                                  | 647                                                   | 46                                                   |
| Central sub-Saharan Africa | 364,894   | (327,646 to 405,768)                    | 331                                                  | -7,4        | (-11,7 to -4,5)                     | 498,074                                              | (473,461 to 526,322)                                 | 637                                                   | 25                                                   |
| Angola                 | 89,553      | (80,374 to 99,729)                      | 378                                                  | -12,8       |                                 | 123,421                                              | (115,993 to 132,673)                                 | 727                                                   | 64                                                   |
| Central African Republic | 14,436     | (12,954 to 16,183)                      | 299                                                  | 5,7         |                                 | 18,918                                               | (17,855 to 20,081)                                  | 487                                                   | 57                                                   |
| Congo (Brazzaville)    | 15,810      | (14,211 to 17,456)                      | 356                                                  | -2,4        | (-4,4 to -0,2)                     | 23,576                                               | (22,053 to 25,886)                                  | 711                                                   | 153                                                  |
| Democratic Republic of the Congo | 235,694 | (211,454 to 262,391)                   | 315                                                  | -6,6        | (-8,6 to -4,6)                     | 316,583                                              | (300,808 to 333,697)                                 | 599                                                   | -0,5                                                 |
| Equatorial Guinea      | 31,444      | (28,080 to 35,901)                      | 402                                                  | 16,1        |                                 | 5148                                                 | (4920 to 5271)                                      | 799                                                   | 394                                                  |
| Gabon                  | 6257        | (5600 to 6956)                          | 370                                                  | -12,0       |                                 | 10,028                                               | (9590 to 10,472)                                     | 732                                                   | -40                                                  |

95% uncertainty intervals are in parentheses. SDI=Socio-demographic Index.

Table 1: Incidence and prevalence of traumatic brain injury in 2016, and percentage change in age-standardised rates by location, 1990–2016

Methods

Overview

Our approach to measuring TBI and SCI was developed within the GBD 2016 study framework. In the GBD 2016 study, standardised analytic methods were used to estimate incidence, prevalence, and YLDs by age, sex, cause, year, and location. The study was an attempt to use all accessible information about disease and injury occurrence, clinical course, and severity that passed a set of inclusion criteria. The comparability of data was optimised by adjusting for different case definitions, enforcing consistency between data for prevalence, incidence, and cause of death estimates, and predicting estimates for locations with sparse data by borrowing information from other locations and covariates. These methods, data, and criteria are described in more detail in other GBD 2016 reports.”

Detailed elements of the GBD methods for measurement of TBI and SCI (including case definitions and severity definitions), a flowchart for our TBI and SCI estimation, and overall GBD study methods are in appendix I. The measurement of TBI and SCI burden had two key deviations from the standard GBD framework. First, the GBD cause hierarchy categorised both TBI and SCI as being a nature of injury as opposed to a cause of

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## Incidence

| Country                | Incidence (2016) | Age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 | Prevalence (2016) | Age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 |
|------------------------|------------------|-------------------------------------|------------------------------------------------------|------------------|-------------------------------------|------------------------------------------------------|
| **Global**             |                  |                                      |                                                      |                  |                                     |                                                      |
| High SDI               | 276.308          | (216.293 to 355.713)                | -3.6 (-6.7 to 0.2)                                   | 9,247.664        | (8,524.049 to 9,995.539)                  | -1.5 (-3.0 to 0.1)                                    |
| High-middle SDI        | 155.693          | (128.997 to 184.028)                | -13.7 (-18.7 to -8.0)                                | 5,394.307        | (4,994.352 to 6,042.158)                  | -4.8 (-6.0 to -3.3)                                   |
| Middle SDI             | 176.313          | (149.499 to 206.614)                | 1.6 (-0.9 to 1.1)                                   | 5,576.932        | (5,244.937 to 5,941.725)                  | 25.6 (23.4 to 28.0)                                   |
| Low-middle SDI         | 240.432          | (189.305 to 340.476)                | 17.9 (4.2 to 5.0)                                   | 5,141.936        | (4,571.709 to 6,349.080)                  | 22.6 (19.5 to 28.1)                                   |
| Low SDI                | 80.532           | (65.824 to 142.240)                 | -20.0 (-33.2 to -10.1)                               | 1,795.869        | (1,327.167 to 2,961.901)                  | 14.2 (8.1 to 25.5)                                    |
| **High income**        | 287.206          | (223.675 to 372.032)                | -4.3 (-7.7 to -1.1)                                  | 9,699.029        | (8,960.042 to 10,481.324)                 | -2.0 (-3.0 to -0.6)                                   |
| **High-income North America** |          |                                      |                                                      |                  |                                     |                                                      |
| Canada                 | 96.544           | (75.334 to 124.401)                 | -2.5 (-7.3 to 1.9)                                   | 32,468           | (29,854 to 34,927)                       | 0.5 (-2.7 to 3.8)                                    |
| Greenland              | 15               | (12 to 19)                          | -16.5 (-19.0 to -14.0)                               | 388              | (357 to 416)                            | -2.1 (-5.5 to 1.5)                                   |
| USA                    | 91.556           | (71.406 to 117.479)                 | 3.7 (-2.7 to 10.5)                                   | 2,633.160        | (2,427.190 to 2,818.818)                  | -7.3 (-11.1 to -3.0)                                  |
| **Australasia**        | 661.232          | (519.101 to 844.422)                | -2.2 (-8.0 to 2.9)                                   | 240.093          | (220.533 to 259.720)                      | 3.3 (-0.3 to 6.9)                                    |
| Australia              | 555.332          | (436.060 to 709.090)                | -1.3 (-7.1 to 4.1)                                   | 201.658          | (185.041 to 218.197)                      | 3.9 (-0.1 to 7.9)                                    |
| New Zealand            | 355.077          | (293.139 to 1,351)                  | -6.4 (-12.3 to -0.9)                                 | 38,436           | (35,415 to 41,681)                       | 0.0 (-3.5 to 5.4)                                    |
| **High-income Asia Pacific** |          |                                      |                                                      |                  |                                     |                                                      |
| Brunei                 | 83.121           | (64.952 to 102.289)                 | -9.6 (-13.6 to -5.7)                                 | 1,831.823        | (1,686.204 to 1,996.895)                  | 1.1 (-1.3 to 3.9)                                    |
| Japan                  | 36.218           | (28.255 to 46.493)                  | -5.1 (-10.0 to -0.1)                                 | 1,306.337        | (1,202.409 to 1,424.185)                  | 5.0 (2.1 to 8.8)                                     |
| Singapore              | 1,000            | (786 to 1,269)                      | -2.0 (-2.5 to 6.5)                                   | 39,555           | (36,218 to 43,598)                       | 15.6 (10.1 to 21.3)                                   |
| South Korea            | 139.090          | (108.960 to 173.339)                | -17.2 (-21.2 to -12.3)                               | 481.913          | (440.648 to 527.192)                      | -8.1 (-11.6 to -4.4)                                  |
| **Western Europe**     | 125.957          | (88.463 to 184.312)                 | -6.8 (-10.8 to -3.5)                                 | 4,979.097        | (4,686.006 to 4,766.288)                  | 1.4 (-1.6 to 2.5)                                    |

(Continued on next page)
| Country                  | 2016 counts          | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990-2016 | 2016 counts          | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990-2016 |
|--------------------------|----------------------|------------------------------------------|------------------------------------------------------|----------------------|------------------------------------------|------------------------------------------------------|
| (Continued from previous page) |                      |                                          |                                                      |                      |                                          |                                                      |
| Germany                  | 22 047               | (16 728 to 28 901)                       | -5.6                                                 | 837 659              | (768 821 to 912 498)                    | 3.0                                                  |
| Greece                   | 2627                 | (20 365 to 33 813)                       | -7.9                                                 | 111 122              | (102 610 to 121 509)                    | -3.7                                                 |
| Iceland                  | 84                   | (65 to 108)                              | -1.2                                                 | 3138                 | (286 834 to 346 550)                    | 7.6                                                  |
| Ireland                  | 1250                 | (964 to 1625)                            | 5.4                                                  | 48 263               | (41 550 to 53 440)                      | 13.3                                                 |
| Israel                   | 1696                 | (12 532 to 25 112)                       | -0.2                                                 | 73 837               | (62 837 to 94 545)                      | 18.9                                                 |
| Italy                    | 16 890               | (13 932 to 21 903)                       | -6.0                                                 | 657 779              | (602 165 to 725 620)                    | -23.9                                                |
| Luxembourg               | 158                  | (121 to 206)                             | -21.0                                                | 5725                 | (524 0 to 626 666)                      | -16.6                                                |
| Malta                    | 109                  | (84 to 141)                              | -7.8                                                 | 4474                 | (408 892 to 492 631)                    | -0.1                                                 |
| Netherlands              | 4019                 | (3104 to 5168)                           | 3.0                                                  | 152 583              | (141 164 to 164 905)                    | 8.7                                                  |
| Norway                   | 1498                 | (12 392 to 19 813)                       | 0.5                                                  | 52 434               | (47 800 to 58 663)                      | 9.7                                                  |
| Portugal                 | 2425                 | (18 988 to 23 173)                       | -23.3                                                | 92 650               | (85 996 to 100 266)                     | -18.2                                                |
| Spain                    | 11 337               | (8 741 to 14 624)                        | -6.4                                                 | 464 842              | (427 508 to 508 351)                    | -9.0                                                 |
| Sweden                   | 2719                 | (20 838 to 35 556)                       | -28.3                                                | 79 465               | (73 587 to 85 786)                      | -3.9                                                 |
| Switzerland              | 2379                 | (17 932 to 31 315)                       | -23.0                                                | 613 245              | (561 180 to 67 232)                     | 2.5                                                  |
| UK                       | 16 215               | (12 431 to 21 182)                       | -4.5                                                 | 913                  | (811 to 1017)                          | -0.2                                                 |
| Argentina                | 8 866                | (6 429 to 10 010)                        | 10.3                                                 | 264 246              | (227 908 to 265 490)                    | 7.0                                                  |
| Chile                    | 3162                 | (26 622 to 42 868)                       | -5.5                                                 | 104 731              | (96 919 to 112 518)                     | -14.2                                                |
| Uruguay                  | 677                  | (533 to 851)                             | 4.9                                                  | 19 745               | (18 625 to 21 341)                      | 20.9                                                 |
| Central Europe, eastern Europe, and central Asia | 77 852 | (63 320 to 94 211) | -2 | (-7.3 to -3.1) | 2 371 936 | (2 210 605 to 2 553 070) | 2.5 | (-0.1 to 7.0) |
| Eastern Europe | 41 674 | (34 038 to 50 176) | 19 | (16 to 23) | -4.2 | (-7.9 to -1.4) | 1 222 360 | (1 141 216 to 1 306 976) | -1.0 | (-3.9 to 2.7) |
| Belarus                  | 2111                 | (1 719 to 25 787)                        | -14.2                                                | 62 574               | (58 133 to 66 705)                      | -12.8                                                |
| Estonia                  | 249                  | (201 to 304)                             | -8.0                                                 | 8391                 | (77 940 to 90 006)                      | -20.4                                                |
| Latvia                   | 383                  | (310 to 470)                             | -20.4                                                | 11 905               | (11 114 to 12 553)                      | -12.1                                                |
| Lithuania                | 653                  | (527 to 798)                             | -3.8                                                 | 19 428               | (18 014 to 20 800)                      | 1.8                                                  |
| Moldova                  | 652                  | (537 to 776)                             | -15.7                                                | 20 939               | (19 342 to 22 699)                      | -9.0                                                 |
| Russia                   | 29 681               | (24 253 to 35 758)                       | -4.1                                                 | 847 799              | (789 186 to 90 826)                     | -13.3                                                |

(Table 2 continues on next page)
| Country                      | 2016 counts | 2016 age-standardised rates (per 100 000) | Percentage change in age-standardised rates, 1990-2016 | Prevalence | 2016 counts | 2016 age-standardised rates (per 100 000) | Percentage change in age-standardised rates, 1990-2016 |
|------------------------------|-------------|----------------------------------------|---------------------------------------------------|------------|-------------|----------------------------------------|---------------------------------------------------|
| (Continued from previous page)                                 |
| Ukraine                      | 7945        | 18                                     | -6.3 (–9.7 to –2.8)                                | 251374     | 484         | -2.6 (–6.3 to 1.7)                      |
| Central Europe               | 24512       | 20                                     | -3.3 (–6.4 to –0.6)                                | 812242     | 597         | 12.1 (8.8 to 17.9)                      |
| Albania                      | 463         | 16                                     | 10.4 (5.3 to 15.3)                                 | 17030      | 537         | 20.0 (18.0 to 36.0)                     |
| Bosnia and Herzegovina       | 621         | 17                                     | 32.5 (27.6 to 38.0)                                | 33351      | 739         | 91.8 (50.9 to 184.2)                    |
| Bulgaria                     | 1331        | 19                                     | -6.1 (–10.4 to –1.8)                               | 47216      | 533         | 0.0 (-3.7 to 3.5)                       |
| Croatia                      | 877         | 18                                     | -3.7 (–9.7 to –2.2)                                | 27754      | 549         | 12.6 (-4.0 to 46.6)                     |
| Czech Republic               | 2691        | 24                                     | -4.5 (–10.0 to 1.1)                                | 91860      | 728         | 19.1 (14.4 to 24.6)                     |
| Hungary                      | 2256        | 21                                     | -1.7 (–2.2 to –1.2)                                | 64731      | 554         | 4.1 (-0.6 to 8.5)                       |
| Macedonia                    | 350         | 17                                     | 17.5 (12.9 to 21.9)                                | 12171      | 518         | 21.7 (16.7 to 27.2)                     |
| Montenegro                   | 117         | 19                                     | 8.0 (4.8 to 11.4)                                  | 3952       | 564         | 11.6 (8.2 to 15.7)                      |
| Poland                       | 8501        | 21                                     | 0.9 (–3.6 to 5.0)                                  | 26715      | 589         | 5.1 (11.2 to 19.5)                      |
| Romania                      | 2972        | 20                                     | -10.3 (–15.0 to –5.9)                               | 29274      | 571         | -5.5 (-9.3 to –2.0)                     |
| Serbia                       | 1542        | 18                                     | 13.7 (10.3 to 17.4)                                | 60445      | 604         | 36.8 (20.9 to 72.7)                     |
| Slovakia                     | 1189        | 21                                     | -9.4 (–13.1 to –5.5)                                | 37606      | 588         | 5.7 (2.1 to 9.4)                        |
| Slovenia                     | 605         | 26                                     | -0.8 (–6.9 to 7.3)                                  | 18638      | 732         | 14.5 (10.1 to 18.8)                     |
| Central Asia                 | 11666       | 13                                     | -0.9 (–3.1 to 1.4)                                  | 337334     | 391         | 5.4 (1.8 to 12.0)                       |
| Armenia                      | 381         | 13                                     | -12.5 (–18.5 to –6.6)                               | 17219      | 518         | -5.9 (-23.6 to –7.2)                    |
| Azerbaijan                   | 1233        | 13                                     | -3.0 (–6.3 to 0.4)                                  | 41913      | 407         | 14.1 (5.8 to 30.9)                      |
| Georgia                      | 514         | 13                                     | -5.6 (–9.2 to –2.0)                                 | 17389      | 395         | 4.3 (-4.5 to 22.4)                      |
| Kazakhstan                   | 2777        | 15                                     | 5.8 (1.7 to 10.0)                                   | 74482      | 419         | 7.5 (4.5 to 9.9)                        |
| Kyrgyzstan                   | 751         | 12                                     | -14.3 (–17.8 to –10.9)                              | 19731      | 354         | -6.7 (-11.4 to –2.0)                    |
| Mongolia                     | 496         | 16                                     | 34.1 (19.4 to 44.4)                                 | 12043      | 405         | 39.1 (34.1 to 44.5)                     |
| Tajikistan                   | 1012        | 11                                     | -11.5 (–15.0 to –8.1)                               | 31335      | 416         | 20.8 (-2.8 to 7.0)                      |
| Turkmenistan                 | 671         | 12                                     | 0.2 (–3.4 to 3.8)                                   | 18298      | 344         | 8.0 (4.7 to 11.4)                       |
| Uzbekistan                   | 3831        | 12                                     | 37.0 (0.3 to 6.9)                                   | 104924     | 355         | 8.0 (5.2 to 11.0)                       |
| Latin America and Caribbean  | 44612       | 8                                      | -4.4 (–8.6 to –1.1)                                 | 1257730    | 222         | 1.2 (-1.1 to 4.3)                       |
| Central Latin America        | 16957       | 7                                      | -14.8 (–19.8 to –11.6)                              | 481048     | 197         | -5.2 (-7.4 to –2.9)                     |

(Table 2 continues on next page)
| Country               | 2016 counts | 2015 age-standardised rates (per 100,000) | Prevalence | 2016 counts | 2015 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 |
|----------------------|-------------|------------------------------------------|------------|-------------|------------------------------------------|-----------------------------------------------|
| Colombia             | 3224        | (2631 to 3876)                           | 102,096    | 210         | (93,911 to 113,136)                      | 4.6                                           |
| Costa Rica           | 348         | (285 to 421)                             | 10,475     | 209         | (96,311 to 11,555)                       | 25.0                                          |
| El Salvador          | 437         | (358 to 528)                             | 16,404     | 282         | (11,867 to 27,532)                       | –10.6                                         |
| Guatemala            | 1134        | (937 to 1355)                            | 28,342     | 209         | (24,201 to 36,840)                       | 6.4                                           |
| Honduras             | 511         | (420 to 615)                             | 14,181     | 193         | (11,288 to 16,888)                       | 48.5                                          |
| Mexico               | 8211        | (6810 to 9858)                           | 218,025    | 277         | (202,252 to 234,802)                     | –17.9                                         |
| Nicaragua            | 374         | (309 to 449)                             | 14,630     | 260         | (10,612 to 23,865)                       | –11.3                                         |
| Panama               | 285         | (234 to 345)                             | 8,224      | 212         | (7,588 to 8872)                          | 21.8                                          |
| Venezuela            | 2424        | (1985 to 2928)                           | 6,861      | 223         | (6,427 to 7,699)                         | 20.8                                          |
| Andean Latin America | 4900        | (4107 to 5740)                           | 134,761    | 241         | (124,709 to 147,122)                     | 10.6                                          |
| Bolivia              | 858         | (709 to 1002)                            | 21,669     | 218         | (19,934 to 23,636)                       | 6.5                                           |
| Ecuador              | 1553        | (1,249 to 1,947)                        | 36,335     | 236         | (33,447 to 39,419)                       | 11.6                                          |
| Peru                 | 2489        | (2075 to 2913)                           | 76,757     | 251         | (70,427 to 84,881)                       | 11.3                                          |
| Caribbean            | 3748        | (3111 to 4449)                           | 120,881    | 263         | (99,280 to 156,635)                      | 49.7                                          |
| Antigua and Barbuda  | 7           | (6 to 8)                                 | 220        | 241         | (203 to 257)                             | 15.6                                          |
| The Bahamas          | 30          | (79 to 100)                              | 906        | 220         | (842 to 972)                             | 15.7                                          |
| Barbados             | 20          | (16 to 23)                               | 662        | 212         | (616 to 709)                             | 20.4                                          |
| Belize               | 28          | (24 to 34)                               | 711        | 212         | (675 to 770)                             | 23.6                                          |
| Bermuda              | 5           | (4 to 6)                                 | 174        | 241         | (161 to 186)                             | 15.7                                          |
| Cuba                 | 1054        | (853 to 1310)                            | 31,067     | 236         | (28,803 to 33,423)                       | 17.8                                          |
| Dominica             | 5           | (4 to 6)                                 | 158        | 208         | (145 to 170)                             | 31.1                                          |
| Dominican Republic   | 770         | (636 to 920)                             | 220        | 220         | (202,428 to 23,753)                      | 33.8                                          |
| Grenada              | 8           | (7 to 10)                                | 70         | 220         | (220,248 to 23,753)                      | 24.8                                          |
| Guyana               | 59          | (49 to 70)                               | 1433       | 191         | (136 to 1527)                            | 16.6                                          |
| Haiti                | 938         | (747 to 1180)                            | 37,949     | 381         | (18,897 to 72,460)                       | 177.3                                         |
| Jamaica              | 194         | (161 to 230)                             | 5733       | 202         | (5309 to 6147)                           | 30.1                                          |
| Puerto Rico          | 319         | (260 to 386)                             | 9695       | 239         | (9034 to 10,384)                         | 28.9                                          |
| Saint Lucia          | 13          | (11 to 15)                               | 408        | 213         | (378 to 436)                             | 24.3                                          |

(Continued from previous page)
| Country                        | Incidence | Prevalence |
|-------------------------------|-----------|------------|
|                               | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 |
|                               | 1990–2016  | (95% CI)   | (95% CI)   | 1990–2016  | (95% CI)   | (95% CI)   |
| Saint Vincent and the Grenadines | 9         | (7 to 10)  | 20        | (15.8 to 25.1) | 242        | (224 to 259) | (18.6 to 27.7) |
| Suriname                      | 41        | (35 to 49) | 8         | (20.2)       | 1180       | (1092 to 1273) | (15.8 to 26.5) |
| Trinidad and Tobago           | 98        | (81 to 118) | 8         | (12.9)       | 3186       | (2961 to 3403) | (28.2 to 37.7) |
| Virgin Islands                | 9         | (7 to 10)  | 8         | (13.3)       | 254        | (236 to 273)  | (13.3 to 20.7) |
| Tropical Latin America        | 19006     | (15 547 to 22 905) | 9         | (6.4)       | 521040     | (484 365 to 555 898) | (–4.9 to 0.0) |
| Brazil                        | 1893      | (15 141 to 22 293) | 9         | (–0.6 to 5.0) | 507 588    | (472 136 to 542 766) | (–5.2 to 0.4) |
| Paraguay                      | 503       | (413 to 606) | 8         | (28.4)      | 13 452     | (12 233 to 14 741) | (15.6 to 24.0) |
| Southeast Asia, east Asia, and Oceania | 147 786   | (123 214 to 177 266) | 7         | (8.9)       | 5 355 950  | (5 008 161 to 5 755 826) | (28.6 to 36.2) |
| East Asia                     | 101 644   | (84 599 to 122 719) | 7         | (10.0)      | 3 851 775  | (3 621 716 to 4 082 414) | (27.4 to 34.0) |
| China                         | 98 216    | (81 760 to 118 651) | 7         | (9.3)       | 3 759 610  | (3 515 971 to 3 963 481) | (17.7 to 33.9) |
| North Korea                   | 1767      | (1466 to 2124) | 7         | (–6.8)      | 49 176     | (46 201 to 52 190)  | (18.6 to 31.8) |
| Taiwan (province of China)    | 1650      | (1368 to 1999) | 7         | (21.6)      | 62 989     | (59 405 to 66 948)  | (25.6 to 33.7) |
| Southeast Asia                | 45 349    | (38 407 to 54 280) | 7         | (6.4)       | 1 486 699  | (1 324 441 to 1 766 643) | (26.7 to 47.9) |
| Cambodia                      | 1020      | (860 to 1206) | 7         | (11.2 to 18.2) | 5 381       | (5 023 to 5 756)  | (16.9 to 22.3) |
| Indonesia                     | 16 383    | (13 827 to 19 498) | 7         | (–3.9)      | 2 141      | (1 966 to 2 316)  | (21.4 to 44.5) |
| Laos                          | 444       | (372 to 528) | 6         | (–26.8)     | 1 090      | (931 to 1 071)   | (47.8 to 53.3) |
| Malaysia                      | 2304      | (1920 to 2798) | 8         | (23.2)      | 70 211     | (66 034 to 74 696) | (26.5 to 33.7) |
| Maldives                      | 20        | (17 to 23)  | 6         | (–0.8)      | 632        | (585 to 678)    | (30.6 to 36.7) |
| Mauritius                     | 81        | (68 to 96)  | 7         | (30.3)      | 2866       | (269 8 to 305 2)  | (41.9) |
| Myanmar                       | 3367      | (2848 to 3916) | 6         | (25.6)      | 137 785    | (129 731 to 145 840) | (38.7 to 46.3) |
| Philippines                   | 7921      | (6314 to 10 612) | 8         | (7.5)       | 204 930    | (178 886 to 256 102) | (28.6) |
| Sri Lanka                     | 1953      | (1350 to 1855) | 8         | (–84.7)     | 94 402     | (81 940 to 107 102) | (48.8 to 161.0) |
| Seychelles                    | 8         | (6 to 9)    | 8         | (24.9)      | 225        | (211 to 240)    | (28.2 to 40.3) |
| Thailand                      | 5507      | (4550 to 6744) | 8         | (16.5)      | 186 063    | (175 707 to 197 225) | (26.3 to 33.2) |
| Timor-Leste                   | 69        | (59 to 81)  | 6         | (–7.0)      | 5688       | (5214 to 6372)   | (21.1 to 65.7) |
| Vietnam                       | 6571      | (5510 to 7844) | 7         | (36.7)      | 196 504    | (184 525 to 208 822) | (28.1 to 55.7) |

(Continued from previous page)
## Incidence

| Country                   | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 |
|---------------------------|-------------|----------------------------------------|---------------------------------------------------|-------------|----------------------------------------|---------------------------------------------------|
| **Oceania**               |             |                                        |                                                   |             |                                        |                                                   |
| American Samoa            | 793         | (672 to 941)                           | 7 (6 to 9)                                        | 12·5        | (-1·5 to 21·8)                         | 17 477 (16 227 to 18 776)                         |
| Federated States of Micronesia | 7          | (5 to 7)                               | 7 (6 to 8)                                        | 7           | 9 (6 to 9)                             | 172 (159 to 186)                                 |
| Fiji                      | 56          | (47 to 66)                             | 7 (6 to 8)                                        | 29·3        | (24·6 to 35·0)                         | 1533 (1431 to 1641)                              |
| Guam                      | 14          | (12 to 17)                             | 8 (6 to 10)                                       | 24·7        | (20·0 to 29·9)                         | 4180 (384 to 454)                                |
| Kiribati                  | 233         | (6 to 9)                               | 7 (6 to 9)                                        | 25·7        | (26·7 to 37·0)                         | 460 (418 to 506)                                 |
| Marshall Islands          | 5           | (4 to 6)                               | 5 (6 to 8)                                        | 21·3        | (16·8 to 26·6)                         | 108 (101 to 116)                                 |
| Northern Mariana Islands  | 10          | (8 to 12)                              | 8 (6 to 10)                                       | 6·8         | (3·9 to 10·1)                          | 288 (268 to 309)                                 |
| Papua New Guinea          | 562         | (47 to 66)                             | 7 (6 to 9)                                        | 8           | (9·5 to 19·7)                          | 11 718 (10 834 to 12 664)                        |
| Samoa                     | 14          | (12 to 16)                             | 7 (6 to 9)                                        | 18·4        | (14·3 to 23·1)                         | 344 (318 to 377)                                 |
| Solomon Islands           | 41          | (34 to 48)                             | 7 (6 to 8)                                        | 22·3        | (17·7 to 28·0)                         | 856 (794 to 919)                                 |
| Tonga                     | 7           | (6 to 9)                               | 7 (6 to 9)                                        | 14·1        | (8·8 to 19·7)                          | 175 (163 to 186)                                 |
| Vanuatu                   | 19          | (16 to 22)                             | 7 (6 to 8)                                        | 27·2        | (22·1 to 33·1)                         | 406 (374 to 444)                                 |
| **North Africa and Middle East** | 114 545   | (60 192 to 250 395)                    | 19 (10 to 40)                                     | 69·6        | (1·2 to 219·0)                         | 85 429 (15 982 973 to 4 560 625)                 |
| Afghanistan               | 14 304      | (44 404 to 38 406)                     | 37 (11 to 101)                                    | 167·8       | (1·11·4 to 41·0)                       | 313 721 (101 927 to 653 389)                     |
| Algeria                   | 3 654       | (2785 to 38 485)                       | 8 (7 to 10)                                       | 5·6         | (-7·9 to -2·7)                         | 106 341 (90 415 to 124 577)                      |
| Bahrain                   | 122         | (104 to 145)                           | 9 (8 to 11)                                       | 3·9         | (-8·5 to -0·1)                         | 4 500 (4 186 to 4 828)                           |
| Egypt                     | 7493        | (6726 to 9128)                         | 8 (7 to 10)                                       | 24·4        | (16·5 to 43·7)                         | 201 767 (184 848 to 225 697)                     |
| Iran                      | 7322        | (6167 to 8763)                         | 9 (8 to 11)                                       | 56·2        | (-76·0 to -21·2)                       | 388 904 (258 799 723 827)                        |
| Iraq                      | 16 663      | (5631 to 47 047)                       | 37 (13 to 105)                                    | 236·9       | (25·5 to 701·4)                        | 388 270 (147 340 to 1027 960)                    |
| Jordan                    | 1204        | (663 to 1460)                          | 14 (8 to 30)                                      | 68·3        | (-7·2 to 246·7)                        | 16 977 (15 689 to 18 348)                        |
| Kuwait                    | 365         | (308 to 429)                           | 10 (8 to 11)                                      | -6·4        | (-8·65 to -18·1)                       | 13 892 (12 640 to 16 107)                        |
| Lebanon                   | 669         | (449 to 1195)                          | 12 (8 to 21)                                      | -6·7        | (-8·2 to -39·3)                        | 91 954 (33 042 352 to 252 384)                   |
| Libya                     | 1269        | (585 to 2331)                          | 20 (10 to 51)                                     | 146·1       | (19·9 to 712·5)                        | 36 616 (19 378 to 78 295)                        |
| Morocco                   | 2466        | (2084 to 2896)                         | 7 (6 to 9)                                        | -1·6        | (-7·0 to 0·9)                          | 82 368 (76 645 to 88 686)                        |
| Oman                      | 461         | (381 to 559)                           | 10 (8 to 12)                                      | -3·3        | (-7·0 to 0·1)                          | 14 520 (13 596 to 15 636)                        |
| Palestine                 | 504         | (400 to 668)                           | 9 (7 to 11)                                       | -24·3       | (-5·3 to 7·5)                          | 21 989 (11 872 to 48 698)                        |

(Continued from previous page)
(Continued from previous page)

| Incidence | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990-2016 | Prevalence | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990-2016 |
|-----------|-------------|------------------------------------------|----------------------------------------------------------|------------|-------------|------------------------------------------|----------------------------------------------------------|
| Qatar     | 265         | (219 to 320)                             | (10 to 14)                                               | -3.5       | 8887        | (8206 to 9463)                           | (351 to 399)                                               | 3.3          | (9.0 to 5.8) |
| Saudi Arabia | 2948       | (2498 to 3469)                           | (8 to 11)                                                | -13.6      | 89085       | (83584 to 94849)                         | (274 to 308)                                               | -8.2         | (-10.2 to -5.7) |
| Sudan     | 4274        | (3005 to 67/5)                           | (7 to 16)                                                | 8.0        | 103888      | (78480 to 166051)                        | (227 to 477)                                               | 27.4         | (20.2 to 39.1) |
| Syria     | 27 672      | (5097 to 90 873)                         | (25 to 441)                                             | 187.0      | 159497      | (64 351 to 401 256)                      | (367 to 2049)                                              | 228.8        | (71.6 to 485.6) |
| Tunisia   | 1 966       | (808 to 1172)                            | (7 to 11)                                               | 9.1        | 31176       | (18 902 to 23 771)                      | (194 to 290)                                               | 137.7        | (1.0 to 17.9) |
| Turkey    | 7235        | (5931 to 9464)                           | (8 to 12)                                               | -6.0       | 221112      | (212 709 to 258 146)                     | (265 to 321)                                               | 1.8          | (-7.6 to 9.1) |
| United Arab Emirates | 1051 | (870 to 1261) | (9 to 13)                                           | -8.9        | 35473       | (33 003 to 37 961)                      | (315 to 360)                                               | -3.1         | (-5.8 to -0.3) |
| Yemen     | 13 802      | (4761 to 37 003)                         | (15 to 111)                                             | 408.7      | 75800       | (55 113 to 129 308)                      | (235 to 509)                                               | 20.1         | (8.0 to 38.6) |
| South Asia | 180 120     | (151 167 to 213 759)                     | (10 to 13)                                             | -2.1       | 412720      | (3 895 776 to 4 387 308)                 | (242 to 272)                                               | 20.3         | (18.3 to 22.7) |
| Bangladesh | 14 525     | (12 239 to 17 308)                       | (8 to 11)                                               | 5.0        | 368 238     | (340 422 to 405 978)                     | (226 to 270)                                               | 35.7         | (29.0 to 44.2) |
| Bhutan    | 81         | (68 to 96)                               | (9 to 13)                                               | 0.3        | 2043        | (1913 to 2192)                           | (259 to 295)                                               | 26.6         | (23.0 to 31.1) |
| India     | 143 743     | (120 391 to 1 759 993)                   | (10 to 14)                                              | -8.4        | 325276      | (3 074 402 to 3 448 115)                 | (243 to 272)                                               | 17.5         | (16.0 to 19.0) |
| Nepal     | 2870        | (2421 to 3380)                           | (8 to 12)                                               | 0.1        | 62575       | (65 750 to 78 982)                      | (236 to 293)                                               | 38.9         | (29.0 to 56.2) |
| Pakistan  | 18 902      | (16 015 to 22 050)                       | (9 to 12)                                               | 14.1       | 435 044     | (402 203 to 472 539)                     | (237 to 274)                                               | 30.0         | (24.4 to 38.7) |
| Sub-Saharan Africa | 82 830 | (70 088 to 98 128)                      | (7 to 10)                                               | -30.4      | 1 811 559   | (1 537 081 to 2 405 237)                 | (194 to 219)                                               | 12.6         | (6.2 to 24.2) |
| Southern sub-Saharan Africa | 6189 | (5194 to 7421) | (7 to 10)                                           | -26.5      | 14 4222     | (13 050 205 to 151 679)                  | (128 to 209)                                               | -12.6        | (-15.7 to -11.1) |
| Botswana  | 190         | (158 to 227)                             | (7 to 10)                                               | 12.6       | 4289        | (4000 to 4585)                           | (183 to 206)                                               | 8.7          | (6.7 to 10.8) |
| eSwatini  | 113         | (94 to 135)                              | (7 to 10)                                               | 13.2       | 1963        | (1826 to 2104)                           | (153 to 173)                                               | -6.5         | (-8.3 to -4.6) |
| Lesotho   | 171         | (143 to 203)                             | (7 to 10)                                               | 18.4       | 2796        | (2594 to 2995)                           | (125 to 141)                                               | -10.6        | (-12.9 to -7.8) |
| Namibia   | 185         | (155 to 219)                             | (6 to 9)                                                | 0.4        | 3987        | (3697 to 4282)                           | (163 to 186)                                               | 5.5          | (3.2 to 8.0) |
| South Africa | 4444        | (2702 to 5367)                           | (7 to 10)                                               | -29.5      | 107 631     | (99 619 to 118 334)                      | (191 to 228)                                               | -16.4        | (-18.9 to -13.6) |
| Zimbabwe  | 1084        | (820 to 1267)                            | (6 to 8)                                                | -0.4       | 19 556      | (18 025 to 21 070)                      | (149 to 207)                                               | 1.0          | (1.2 to 2.0) |
| Western sub-Saharan Africa | 33 433 | (28 312 to 39 509) | (7 to 10)                                           | -6.7       | 64 8235     | (588 267 to 723 553)                     | (186 to 226)                                               | 10.1         | (6.0 to 19.1) |
| Benin     | 906         | (768 to 1067)                            | (7 to 10)                                               | 1.8        | 17 000      | (15 734 to 18 325)                      | (175 to 200)                                               | 5.4          | (3.1 to 7.6) |
| Burkina Faso | 1512       | (1275 to 1779)                           | (7 to 10)                                               | -2.6       | 26 537      | (24 449 to 28 527)                      | (167 to 190)                                               | 11.1         | (8.6 to 13.2) |
| Cameroon  | 2059        | (1721 to 2448)                           | (7 to 11)                                               | 6.1        | 36183       | (33 240 to 39 021)                      | (166 to 192)                                               | -1.5         | (-4.2 to 1.9) |
| Cape Verde | 45         | (38 to 52)                               | (7 to 10)                                               | 9.4        | 1109        | (1029 to 1189)                           | (210 to 229)                                               | 16.6         | (14.2 to 19.1) |

(Tables 2 continues on next page)
### Articles

| Incidence | Prevalence |
|-----------|------------|
| 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 | 2016 counts | 2016 age-standardised rates (per 100,000) | Percentage change in age-standardised rates, 1990–2016 |
| Chad | 2017 (1038 to 1437) | (7 to 10) | 9 | -0.2 (0.6) | -2.6 | (21 330 to 35 887) | (199 490 to 263 826) | 13 | (-5.7 to 7.2) |
| Côte d’Ivoire | 1968 (1668 to 2297) | (8 to 11) | 9 | -4.6 | -7.1 | (33 288 to 39 550) | (172 201 to 236 200) | 17 | (-1.2 to 6.8) |
| The Gambia | 157 (132 to 184) | (7 to 9) | 8 | -8.2 | -10.1 | (2800 to 3417) | (172 201 to 236 200) | 6.7 | (-11.9 to -3.2) |
| Ghana | 2301 (1953 to 2690) | (7 to 10) | 9 | 15 | (8.0 to 13.0) | 10 | (43 313 to 50 073) | (183 209 to 226 870) | 24 | (-15.9 to 23.3) |
| Guinea | 973 (821 to 1123) | (7 to 9) | 8 | -6.8 | (9.1 to -4.4) | 91 | (15 817 to 19 621) | (159 182 to 195 234) | -5.5 | (-8.5 to -1.0) |
| Guinea-Bissau | 157 (123 to 183) | (7 to 10) | 8 | -8.7 | (10.4 to -6.7) | 99 | (2629 to 3280) | (162 202 to 226 870) | 14 | (-2.2 to 18.3) |
| Liberia | 324 (275 to 379) | (6 to 9) | 7 | -8.5 | (-9.4 to -5.9) | 8 | (7581 to 24 974) | (203 698 to 249 179) | 7.5 | (15.8 to 18.6) |
| Mali | 1427 (1206 to 1699) | (7 to 10) | 8 | -12.4 | (23.3 to -5.9) | 9 | (24 231 to 37 739) | (176 292 to 226 870) | 29 | (10.1 to 77.9) |
| Mauritania | 326 (275 to 382) | (7 to 10) | 9 | -31.1 | (-59.6 to -7.6) | 9 | (6963 to 8060) | (205 235 to 274 932) | 14 | (12.0 to 16.6) |
| Niger | 1546 (1308 to 1825) | (7 to 9) | 8 | -15.3 | (-24.7 to -9.5) | 9 | (23 640 to 27 889) | (157 182 to 226 870) | 2.5 | (-5.1 to 1.0) |
| Nigeria | 16 220 (13 543 to 19 520) | (8 to 11) | 9 | -3 | (-2.7 to -16.5) | 9 | (284 060 to 338 096) | (194 227 to 274 932) | 1.0 | (7.2 to 17.3) |
| São Tomé and Principe | 34 (15 to 21) | (8 to 11) | 9 | -4.0 | (1.4 to 6.5) | 9 | (336 389) | (216 246 to 274 932) | 7.7 | (5.4 to 10.1) |
| Senegal | 1215 (1027 to 1417) | (7 to 10) | 8 | -3.2 | (-8.5 to -0.4) | 9 | (21 961 to 26 655) | (178 205 to 226 870) | 5.4 | (2.3 to 9.7) |
| Sierra Leone | 498 (421 to 582) | (7 to 10) | 8 | -5.2 | (-7.4 to -2.9) | 9 | (10 075 to 23 417) | (188 453 to 226 870) | 5.0 | (7.2 to 15.4) |
| Togo | 555 (468 to 649) | (7 to 9) | 8 | -2.3 | (-4.9 to 0.2) | 9 | (10 662) | (153 182 to 226 870) | 1.6 | (-4.1 to 1.9) |
| Eastern sub-Saharan Africa | 31 178 (27 991 to 39 389) | (8 to 11) | 9 | -48.2 | (-71.0 to -20.4) | 9 | (624 381 to 1 220 333) | (206 441 to 424 082) | 20.4 | (18.0 to 33.0) |
| Burundi | 1045 (878 to 1240) | (9 to 11) | 10 | -3.1 | (-6.0 to -1.1) | 9 | (10 445 to 46 950) | (216 553 to 274 932) | 11.8 | (4.3 to 26.8) |
| Comoros | 63 (53 to 75) | (7 to 10) | 9 | -20.3 | (-22.5 to -18.1) | 9 | (129 145.9) | (192 226 to 274 932) | 10.7 | (7.7 to 14.9) |
| Djibouti | 87 (73 to 102) | (8 to 11) | 9 | -2.4 | (-4.7 to -8.7) | 9 | (175 2107) | (212 255 to 274 932) | 2.8 | (-1.9 to 12.1) |
| Eritrea | 454 (383 to 532) | (8 to 11) | 9 | -3.4 | (-6.2 to -0.4) | 9 | (9461 to 21 689) | (217 506 to 274 932) | 8.0 | (29.8 to 197.0) |
| Ethiopia | 8607 (7299 to 10 139) | (8 to 11) | 9 | -7.5 | (-8.8 to -4.4) | 9 | (172 245 to 34 751) | (213 474 to 274 932) | 13.0 | (6.0 to 19.5) |
| Kenya | 397 (336 to 4640) | (8 to 11) | 9 | 7.3 | (5.9 to 8.7) | 9 | (81 265) | (201 228 to 274 932) | 1.7 | (15.4 to 19.8) |
| Madagascar | 1940 (1630 to 2280) | (7 to 10) | 8 | -6 | (-7.7 to -2.0) | 9 | (33 937 to 39 548) | (166 190 to 226 870) | 2.4 | (-0.3 to 5.5) |
| Malawi | 1280 (1080 to 1504) | (6 to 9) | 7 | -13.4 | (-15.8 to -10.9) | 9 | (21 452) | (136 156 to 192 226) | 4.7 | (-7.7 to -1.7) |
| Mozambique | 2341 (1972 to 2747) | (7 to 10) | 9 | -24.0 | (-53.9 to 0.4) | 9 | (41 299 to 106 216) | (188 595 to 274 932) | 18.8 | (-29.7 to 0.3) |
| Rwanda | 908 (761 to 1067) | (7 to 9) | 8 | -5.4 | (-7.9 to -3.0) | 9 | (32 287 to 224 253) | (346 264 to 274 932) | 45.5 | (106 2 to 1244 1) |
| Somalia | 1709 (1585 to 1837) | (10 to 11) | 16 | -21.3 | (-28.7 to -11.7) | 9 | (27 548) | (209 637 to 274 932) | 33.3 | (6.7 to 71.5) |

(Table 2 continues on next page)
Articles

Incidence

|                  | 2016 counts | 2016 age-standardised rates (per 100 000) | Percentage change in age-standardised rates, 1990-2016 | Prevalence |
|------------------|-------------|-----------------------------------------|------------------------------------------------------|------------|
|                  |             | 2016 counts | 2016 age-standardised rates (per 100 000) | Percentage change in age-standardised rates, 1990-2016 | 2016 counts | 2016 age-standardised rates (per 100 000) | Percentage change in age-standardised rates, 1990-2016 |
| South Sudan      | 1455        | (1258 to 1935) | (9 to 14) | (-59 4 | (-79 6 to -21 2) | 36 330 | (23 858 to 66 348) | (-4 2) | (-9 3 to 9 1) |
| Tanzania         | 4584        | (3883 to 5363) | (7 to 10) | (-4 2 | (-6 3 to -2 1) | 84 663 | (78 171 to 91 074) | (-6 7) | (-8 2 to 4 7) |
| Uganda           | 3215        | (2700 to 3747) | (7 to 10) | (-11 7 | (-29 0 to -1 6) | 76 806 | (57 559 to 123 332) | (-9 5) | (-13 3 to 4 6) |
| Zambia           | 1487        | (1252 to 1747) | (8 to 11) | (-2 5 | (-2 1 to 5 9) | 24 612 | (22 713 to 26 463) | 180 | 2 7 |
| Central sub-Saharan Africa | 10 034 | (8473 to 11 871) | (8 to 11) | (-14 3 | (-29 1 to -5 7) | 218 015 | (177 254 to 213 214) | 243 | 221 |
| Angola           | 2661        | (1958 to 2757) | (8 to 11) | (-38 2 | (-66 6 to -9 8) | 59 309 | (44 232 to 95 567) | 329 | 52 |
| Central African Republic | 434 | (348 to 553) | (7 to 11) | (14 8 | (3 2 to 43 2) | 80 61 | (63 35 to 120 014) | 171 | 329 |
| Congo (Brazzaville) | 426 | (360 to 508) | (8 to 11) | (3 2 | (-3 8 to 5 8) | 11 542 | (84 20 to 19 317) | 302 | 81 9 |
| Democratic Republic of the Congo | 6569 | (5542 to 7777) | (7 to 10) | (-4 5 | (-7 3 to -0 3) | 133 941 | (112 213 to 181 770) | 216 | 27 6 |
| Equatorial Guinea | 81 | (68 to 94) | (9 to 12) | (11 8 | (6 6 to 16 5) | 1697 | (158 4 to 185 0) | 234 | 53 4 |
| Gabon            | 163         | (128 to 191) | (8 to 11) | (-10 9 | (-12 9 to -8 9) | 3464 | (23 19 to 27 20) | 225 | 3 6 |

95% uncertainty intervals are in parentheses. SDI=Socio-demographic Index.

Table 2: Incidence and prevalence of spinal cord injury in 2016, and percentage change in age-standardised rates by location, 1990-2016

...continue from previous page...

incidence—ie, these conditions previously had been measured as consequences of causes of injury. For example, a cause, such as a fall, could lead to SCI. Historically falls have been measured and reported but the actual nature of injury (eg, TBI, ankle fracture) that occurred because of the fall has not been directly reported. This aspect of the GBD study design was consistent across other natures of injuries. Second, estimation of TBI and SCI deviated from the GBD study framework in terms of the measures that were reported for the conditions, because we do not estimate death from TBI or SCI. Although TBI and SCI can lead to death, they were not considered causes of death in the GBD 2016 framework. Instead, the cause of injury (eg, falls) that led to a nature of injury such as TBI was considered the cause of death. For example, an individual who had a fall, sustained a TBI, and then died while in hospital after the injury would be considered to have had a death caused by a fall and an incident TBI. In this study, we estimated the non-fatal burden and therefore report incidence, prevalence, and YLDs, but not cause-specific mortality or years of life lost.

Cause-of-injury estimation

The process for estimation of incidence, prevalence, and YLDs was as follows. First, the incidence of 29 different causes of injury (appendix I) were modelled with DisMod-MR 2.1, a meta-regression tool that was used extensively throughout the GBD study. These cause-of-injury models measured the incidence of each cause of injury that required medical care, which included patients who were admitted or seen in an outpatient clinic and received a diagnosis code for a given cause of injury. Receiving an injury diagnosis code did not preclude the possibility of death in the hospital or after discharge. Each of these cause models used an array of data types, including surveillance studies, literature studies, hospital discharge records, and emergency department records. The details of these models have previously been described in more detail. Although we do not estimate death from TBI or SCI in this study, our modelling strategy also included cause-specific mortality rates from the cause of death ensemble model to inform incidence estimates for cause-of-injury models such as road injuries in data-sparse areas using estimates from data-rich areas. The outputs from these models were estimates of inpatient (admitted) and outpatient incidence rates of causes of injury and were specific for location, sex, age, and year. The outpatient incidence of each cause was derived from the inpatient incidence on the basis of a regression coefficient for outpatient incidence that was extracted from DisMod-MR 2.1 incidence models in locations that had both inpatient and outpatient data.

Nature-of-injury estimation

Clinical record data that coded for both cause and nature of injury were used to estimate the proportion of each cause...
that resulted in each nature of injury. If an injury cause resulted in more than one nature of injury, the most severe was chosen on the basis of a mixed-effects regression model that estimated the disability experienced by an injured individual adjusted for age, sex, and never-injured status, with country and individual random effects. Because SCI was associated with higher disability than TBI (appendix 1), SCI was chosen if both conditions occurred as a result of the same injury. We used this method after finding in a previous GBD study that statistically assigning multiple injury categories to a single individual was difficult because of a sparsity of data. This process and the severity rankings are described in more detail in appendix 1. These proportions were calculated for each external cause-of-injury–nature-of-injury (cause–nature) combination, such that the proportions of all natures of injury for a given cause of injury sum to 1 because of a Dirichlet regression. The output from this step was incidence for each cause–nature combination.

Derivation of incidence, prevalence, and YLDs

From the incidence estimates for each cause–nature combination, we separately modelled short-term and long-term estimates using proportions of individuals expected to experience short-term versus long-term disability (the cutoff for long-term disability was 1 year). The proportions estimated to experience permanent health loss generally increased with age and were different for TBI and SCI (appendix 1). The short-term prevalence estimates were then calculated on the basis of average duration of a short-term case, whereas the long-term estimates were considered to be permanent and underwent comorbidity adjustment as described previously.

Cause–nature incidence rates were converted to prevalence with the differential equation solver used in DisMod-MR 2.1. This solver reconciled the incidence rates from the previous steps with standardised mortality ratios derived from literature studies to estimate prevalence, because people with long-term disability due to TBI and SCI die at a higher rate than the background mortality in the population. The final output from this step was prevalence of each cause–nature combination for each location, year, age, and sex combination.

YLDs were then calculated by multiplying the prevalence by the disability weight. Measurement has been described in more detail previously, but in summary, disability weights were measured through population and internet surveys on the basis of lay descriptions of disabling conditions. For example, the disability weight for short-term mild TBI and for short-term moderate or severe TBI were 0·110 (95% uncertainty interval [UI] 0·074–0·158) and 0·214 (0·141–0·297), respectively.
meaning that the affected people experienced health losses of 11·0% and 21·4%, respectively, compared with a person in full health. All disability weights for different severities of TBI and SCI are provided in appendix 1.

After estimation of YLDs, the prevalence, incidence, and YLDs for TBI and SCI were then summed across all causes to estimate the all-injury prevalence, incidence, and YLDs for TBI and SCI separately. Uncertainty was propagated throughout this process by maintaining distributions of 1000 draws for each estimation stage (including percentage change over time). We use the 25th and 975th sorted values in the draw distributions as the upper and lower UIs for mean estimates and for percentage change, whereby change was judged to be significant if the lower and upper UIs did not overlap zero. This process is consistent with management of uncertainty throughout the GBD study framework.3

Statistical analysis

We grouped countries into quintiles on the basis of their 2016 Socio-demographic Index (SDI) value, which is a composite measure of development derived from income per person, educational attainment, and total fertility rate.5 Additionally, we measured the most common causes of TBI and SCI separately in terms of the original cause of injury that led to the disability. Finally, we measured the proportion of TBI that was mild versus the proportion that was moderate or severe and the proportion of SCI that occurred at the neck versus below the neck and present these values at the global level. Analyses were done in Python (version 2.7), Stata (version 13.1), and R (version 3.3). Statistical code used for this study will be made available upon publication of this Article via the Institute for Health Metrics and Evaluation. This study complies with the Guidelines for Accurate and Transparent Health Estimates Report (GATHER) recommendations (appendix 1).

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or the writing of the report. All authors had full access to the data in the study and had final responsibility for the decision to submit for publication.

Results

We used incidence data for every cause of injury and every GBD region. The number of sources by injury and by region are in appendix 1. Incidence, prevalence, and YLD estimates for every cause of injury by age, sex, and location for 1990–2016 are available through an online results tool.
Figure 3: Global incidence of minor (A) and moderate or severe (B) traumatic brain injury, and of spinal cord injury at neck level (C) and below neck level (D), by age and sex, 2016.

Shaded regions represent 95% uncertainty intervals.

Table 1 shows the incidence and prevalence of TBI in terms of all-age counts, age-standardised rates (per 100 000 population), and percentage change in age-standardised rates between 1990 and 2016. Table 2 shows the same information for SCI. YLDs from TBI and SCI in terms of all-age counts, age-standardised rates, and total percentage change are in appendix 2, which also includes these estimates by age and sex, and for 1990. Between 1990 and 2016, age-standardised incidence rates significantly increased by 3·6% (95% UI 1·8 to 5·5) for TBI and decreased non-significantly by –0·2% (–2·1 to 2·7; table 2). Age-standardised prevalence of TBI was high in the super-region of central Europe, eastern Europe, and central Asia at 1539 (1464–1614) per 100 000, representing roughly 7·5 million prevalent cases (7·1–7·9). Age-standardised prevalence for SCI was highest in high SDI regions—specifically western Europe (854 [780–945] per 100 000) and high-income Asia Pacific (821 [747–907] per 100 000; table 2).

In terms of individuals living with disability from these conditions in 2016, TBI had a global age-standardised prevalence of 759 (95% UI 731–788) per 100 000 (table 1), and SCI had a global age-standardised prevalence of 368 (340–409) per 100 000 (table 2). These estimates corresponded to 55 million (53–58) individuals with TBI and 27 million (25–30) with SCI (for unrounded estimates see table 1). From 1990 to 2016, the age-standardised prevalence of TBI increased by 8·4% (95% UI 7·7–9·2; table 1), whereas that of SCI decreased non-significantly by 0·0% (–2·1 to 2·7; table 2). Age-standardised prevalence of TBI was high in the super-region of central Europe, eastern Europe, and central Asia at 1539 (1464–1614) per 100 000, representing roughly 7·5 million prevalent cases (7·1–7·9). Age-standardised prevalence for SCI was highest in high SDI regions—specifically western Europe (854 [780–945] per 100 000) and high-income Asia Pacific (821 [747–907] per 100 000; table 2).

TBI and SCI caused 8·1 million (95% UI 6·0–10·4) and 9·5 million (6·7–12·4) YLDs, respectively, in 2016. The age-standardised YLD rates were 111 (82–141) per 100 000 for TBI and 130 (90–170) per 100 000 for SCI (appendix 2). The global age-standardised YLD rates per 100 000 population for TBI increased by 8·5% (7·6–9·3) from 1990 to 2016 and those for SCI decreased non-significantly by 10·0% (7·0–13·3) from 1990 to 2016. At the country level, for TBI, the distribution of YLDs was similar to those of incidence and prevalence. Specifically, countries in central Europe, eastern Europe, and central Asia had the highest age-standardised YLD rates, with country-specific rates ranging from 135 (99–175) per 100 000 in Tajikistan to 335 (241–421) per 100 000 in Slovenia. For SCI, the high-income super-region had the highest age-standardised YLD rates (229 [159–303] per 100 000). Within these locations, Finland (287 [197–381] per 100 000), Ireland (283 [192–373] per 100 000), and Israel (282 [181–396] per 100 000) had the highest age-standardised YLD rates.

Figure 3 shows the global age-specific and sex-specific incidence rates per 100 000 for minor TBI, moderate or severe TBI, spinal cord lesions at the neck, and spinal cord lesions below the neck for 2016. For TBI, these figures show divergent patterns between males and females that start in teenage years and extend to ages 50–60 years (figure 3). At older ages (ie, older than 60 years), the sex-specific incidence rates in males and females is similar (figure 3). The incidence is more similar between the sexes for both subtypes of SCI than for TBI, although men have higher incidences than women of spinal cord lesions at the neck level at ages 20–40 years (figure 3).
The proportion of causes leading to TBI and SCI by region are shown in figure 4. In general, falls were the main cause of TBI. In some regions, such as central Europe, more than 50% of the age-standardised incidence of TBI was caused by falls; in other regions, such as Oceania, falls were still the predominant cause but accounted for a smaller proportion of the age-standardised incidence (figure 4). In addition to having high age-standardised incidence, prevalence, and YLDs attributable to TBI, central and eastern Europe also had the highest incidence of TBI caused by falls. The second most common cause of TBI in most regions was motor vehicle road injuries (figure 4A). The main cause of SCI in most regions was also falls, which accounted for more than 50% of age-standardised incidence in nine different GBD regions (figure 4). Conflict and terrorism was the most common cause in North Africa and the Middle East in 2016 (figure 4B).

Discussion
This study, in which we used the GBD framework to estimate the non-fatal burden of TBI and SCI, is to our knowledge the first effort to quantify the burden of these conditions at global, regional, and national levels for all ages and sexes, and over time, from 1990 to 2016. Globally, these conditions cause non-fatal health loss that is distributed across various levels of income, geographies, and the lifespan, and represent a substantial proportion of global injury burden that could be averted through injury prevention and safety measures.

We identified an increase in global age-standardised incidence, prevalence, and YLDs of TBI between 1990 and 2016. This increase probably reflects the increasing rates of falls and road injuries over this period, which could in turn be due to increased use of motor vehicles, unsafe road conditions, and, in some areas, increased rates of alcohol consumption or unsafe infrastructure.22–24 By contrast, we noted no significant change in the age-standardised incidence or prevalence of SCI, although with global population growth, the absolute number of people living with the effects of SCI is expected to increase. The increasing global incidence of both TBI and SCI starting approximately at age 70 years also shows the importance of preventive measures for injuries through all years of life—particularly in the context of an ageing global population—and of adequate access to acute medical care resources such as emergency medical services and emergency department care.

Regional patterns differed between TBI and SCI. The highest incidence rates of TBI were in central Europe, eastern Europe, and central Asia, whereas the highest incidence rates of SCI were in high-income North

Figure 4: Cause composition of age-standardised incidence of traumatic brain injury (A) and spinal cord injury (B) by Global Burden of Disease region for both sexes, 2016.
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In a study done in New Zealand, in which proactive TBI and SCI that can result from road injuries. These variations in the underlying causes of TBI and SCI probably explain much of the geographical variation in the incidence of TBI and SCI. Access to health-care resources could also explain some geographical variation. For example, the higher prevalence of SCI in North America and western Europe could be related to survival bias in high SDI areas, whereby medical services have led to successful resuscitation in injury victims who otherwise would have died without receiving a TBI or SCI diagnosis code. The high rates of TBI in central Europe, eastern Europe, and central Asia generally correspond with the high all-injury rate estimated in those regions in GBD 2016.

Our findings show that, globally, falls and road injuries were the most important cause of non-fatal cases of both TBI and SCI, reflecting the findings for all 328 diseases and injuries from GBD 2016, in which falls were the tenth leading cause of age-standardised YLDs from 1990 to 2016. This burden of falls was particularly evident in our study for central Europe, eastern Europe, and central Asia, where falls were the second most common cause of disability in 1990 and the third most common cause in 2016. Although the context in which a fall occurred could not be established in this study because of a lack of International Classification of Diseases (ICD) coding detail, falls can be preventable irrespective of where they occur. Falls leading to SCI have been associated with alcohol use in countries such as Estonia, so risk factor profiles across countries could explain some geographical patterns in this study. Road injuries were also important causes of these conditions, suggesting that achievement of Sustainable Development Goal 3.6 (“By 2020, halve the number of global deaths and injuries from road traffic accidents”) could reduce the burden of conditions such as TBI and SCI that can result from road injuries.

Our estimates for TBI incidence diverged from estimates in other published literature. Our study relied on cause-of-injury models that by design estimate the incidence of injuries requiring medical care. A limitation of this approach is that some people with TBI, particularly mild TBI, might not seek medical attention after injury and are thus not captured in the analysis, which could lead to underestimation of the global burden of TBI. In a study done in New Zealand, in which proactive screening methods were used to contact people after an accident to their upper body (including use of broad ICD-10 codes [S00–S09] in addition to community-based case-ascertainment sources to identify individuals not seeking medical treatment), the incidence of TBI was 790 per 100000 (substantially higher than that in our study), and approximately 30% of people with mild TBI did not seek medical attention soon after their TBI. However, this study was done in only one country, and the findings can probably not be generalised to the global population. However, the findings of that study emphasise the need for other international studies to use a comprehensive community-based approach for case ascertainment to increase the accuracy of GBD estimates.

In general, our study had similar limitations to other GBD studies, but with the added complexity and uncertainty of measuring TBI and SCI within other injury estimates, which has not been done previously in the GBD framework. In terms of TBI-specific and SCI-specific limitations, we used medical record data extensively in our modelling process, which might not be representative of the entire population. This point is pertinent because most of the dual-coded clinical data that was used in the derivation of cause–nature proportions was from high-income countries. Additionally, the derivation of the incidence coefficient that adjusts for injuries receiving outpatient care was based on limited data. These factors could have introduced selection bias, which was addressed to some extent by incorporation of income and health-care access in our modelling process. However, by relying on medical care records, we potentially did not include people with mild TBI who did not seek medical care, which therefore could be a source of detection bias leading to underestimation, although we addressed this issue by using cause-of-injury incidence models for all injuries requiring medical care, followed by a Dirichlet-based modelling approach of cause–nature combinations. An additional limitation stems from the studies examining how TBI and SCI can occur together. A proportion of people can experience an SCI from a traumatic event and also experience TBI, and because of the disability-ranking approach that we used in our cause–nature proportion analysis, these patients would be assigned SCI as their nature of injury. Experiencing both SCI and TBI can also complicate recovery, and presence of non-brain injuries in people with TBI can affect survival, although estimates of the cumulative effect are outside the scope of this analysis. The ICD codes used to identify SCI cases also include some injuries that do not necessarily lead to paraplegia or tetraplegia, and some such injuries, such as spinal cord contusions, can improve over time. Additionally, emerging evidence about long-term deficits such as dementia, stroke, and increased risk of engagement in antisocial behaviour linked to TBI were not included in our disability computation. The long-term neurological and psychological sequelae of TBI are poorly understood, and the epidemiological, neuropathological, and psychiatric analyses intended to understand the resultant disabilities will be important to incorporate in future assessments. Similarly, our analysis does not capture cohort effects over time, a limitation that can be addressed in future GBD
studies. Overall, the long-term sequelae due to TBI and SCI suggest that further work in terms of measurement of long-term disability is needed to measure the effect of these conditions more accurately, and to ensure that the disability weights accurately reflect the health loss observed in clinical practice and experienced by individuals; such further work could influence future research into disability-weight measurement via health loss surveys. The limitations we describe also show how more research is needed, particularly in low-income areas of the world, to collect comprehensive injury data. Focusing of resources on injury epidemiology data could improve the accuracy of future epidemiological assessments of TBI and SCI.

In conclusion, the age-standardised incidence, prevalence, and YLD of TBI are increasing globally, whereas age-standardised rates of SCI have not changed (although the number of individuals with SCI is likely to be increasing globally). In view of the expense and complexity of managing patients with TBI and SCI, ministries of health, medical systems, and social support infrastructure should focus on development and improvement of injury-prevention strategies, although maintenance of short-term and long-term care pathways to mitigate health loss and improve outcomes among patients with TBI and SCI is also crucial. Finally, measurement of the burden of these conditions could be improved with the establishment of registry systems for patients with TBI and SCI worldwide, which could help to facilitate further research and intervention efforts and improve the accuracy of these important conditions.
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Contributors
SLJ, AT, VLF, RGE, and TV prepared the first draft. MSB, WCM-V, and LRL analysed the data and edited the first draft and final versions of the Article. SLJ, AT, VLF, RGE, and TV finalised all drafts, and approved the final version of the Article. All other authors provided data, developed models, reviewed results, provided guidance on methods, or reviewed the Article, and approved the final version.

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References
1. Maas AIR, Menon DK, Adelson PD, et al. Traumatic brain injury: integrated approaches to improve prevention, clinical care, and research. Lancet Neurol 2017; 16: 987–1048.
2. Te Ao B, Brown P, Tobias M, et al. Cost of traumatic brain injury in New Zealand: evidence from a population-based study. Neurology 2014; 83: 1645–52.
3. GBD 2016 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 2017; 390: 1211–59.
4. Burns JF. In Europe, echoes of America as concussions spur debate. https://www.nytimes.com/2014/09/06/sports/international/echoes-of-america-as-concussions-spur-debate.html (accessed July 13, 2018).
5. Scholten AC, Polinder S, Panneer MJM, van Breeck EF, Haagsma JA. Incidence and costs of bicycle-related traumatic brain injuries in the Netherlands. Accid Anal Prev 2015; 81: 51–60.
6. Emanuels J, I, Wendl T. Epidemiology of traumatic brain injury in children and adolescents in south-western Sweden. Acta Paediatr Oslo Nor 1992 1997; 86: 730–35.
7. Singh A, Tetreault J, Kalsi-Ryan S, Nouri A, Feiheins MG. Global prevalence and incidence of traumatic spinal cord injury. Clin Epidemiol 2014; 6: 309–31.
8. Canadian Institute for Health Information. Head injuries in Canada: a decade of change (1994–1995 to 2003–2004). https://secure.cihi.ca/estore/productFamily.htm?id=PFC1360&lang=fr&media=0 (accessed April 19, 2018).
9. Rutland-Brown W, Langlois JA, Thomas KE, Xi YL. Incidence of traumatic brain injury in the United States, 2003. J Head Trauma Rehabil 2006; 21: 544–48.
10. Bruns J, Hausner WA. The epidemiology of traumatic brain injury: a review. Epilepsia 2003; 44 (suppl 10): 2–10.
11. Taylor CA. Traumatic brain injury-related emergency department visits, hospitalizations, and deaths—United States, 2007 and 2013. MMWR Surveill Summ 2017; 66: 1–16.
12. Chiu W-T, Lin H-C, Lam C, Chu S-F, Chiang Y-H, Tsai S-H. Review paper: epidemiology of traumatic spinal cord injury: comparisons between developed and developing countries. Asia Pac J Public Health 2010; 22: 9–18.
13. Rahimi-Movaghar V, Sayyah MR, Alkahi H, et al. Epidemiology of traumatic spinal cord injury developing in countries: a systematic review. Neuroepidemiology 2013; 41: 65–85.
14. GBD 2016 Causes of Death Collaborators. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 2017; 390: 1151–210.
15. GBD 2016 Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 2017; 390: 1345–422.
16. GBD 2016 DALYs and HALE Collaborators. Global, regional, and national disability-adjusted life-years for 334 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 2017; 390: 1200–344.
17. GBD 2016 Mortality Collaborators. Global, regional, and national under-5 mortality, adult mortality, age-specific mortality, and life expectancy, 1970–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 2017; 390: 1084–150.
18. Foreman KJ, Lozano R, Lopez AD, Murray CJ. Modeling causes of death: an integrated approach using CODEm. Popul Health Metr 2012; 10: 1.
19. Vos T, Flaxman AD, Naghavi M, et al. Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012; 380: 1213–96.

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Moorin R, Miller TR, Hendrie D. Population-based incidence and 5-year survival for hospital-admitted traumatic brain and spinal cord injury, Western Australia, 2003–2008. J Neurol 2014; 261: 1726–34.

Salomon JA, Haagsma JA, Davis A, et al. Disability weights for the Global Burden of Disease 2013 study. Lancet Glob Health 2015; 3: e712–23.

Sabre I, Pedai G, Rekand T, Asser T, Linnamägi U, Körv J. High incidence of traumatic spinal cord injury in Estonia. Spinal Cord 2012; 50: 755–59.

Salomon JA, Haagsma JA, Davis A, et al. Disability weights for the Global Burden of Disease 2013 study. Lancet Glob Health 2015; 3: e712–23.

Sabre I, Pedai G, Rekand T, Asser T, Linnamägi U, Körv J. High incidence of traumatic spinal cord injury in Estonia. Spinal Cord 2012; 50: 755–59.

WHO. Road traffic injuries. http://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries (accessed July 17, 2018).

WHO. Falls. http://www.who.int/news-room/fact-sheets/detail/falls (accessed July 17, 2018).

UNDP. Goal 3 targets. http://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-3-good-health-and-well-being/targets.html (accessed July 16, 2018).

Barker-Collo SL, Feigin VL. Capturing the spectrum: suggested standards for conducting population-based traumatic brain injury incidence studies. Neuroepidemiology 2009; 32: 1–3.

Barker-Collo SL, Feigin VL. Capturing the spectrum: suggested standards for conducting population-based traumatic brain injury incidence studies. Neuroepidemiology 2009; 32: 1–3.

Barker-Collo SL, Feigin VL, Kahan M. Accuracy of an International Classification of Diseases code surveillance system in the identification of traumatic brain injury. Neuroepidemiology 2016; 47: 46–52.

Feigin VL, Theadom A, Barker-Collo S, et al. Incidence of traumatic brain injury in New Zealand: a population-based study. Lancet Neurol 2013; 12: 53–64.

Budisin B, Bradbury CCLB, Sharma B, et al. Traumatic brain injury in spinal cord injury: frequency and risk factors. J Head Trauma Rehabil 2016; 31: e33-42.

Brown AW, Leibson CL, Mandrekar J, Ransom JR, Malec JF. Long-term survival after traumatic brain injury: a population-based analysis controlled for nonhead trauma. J Head Trauma Rehabil 2016; 29: e1–8.

Chen Y-H, Kang J-H, Lin H-C. Patients with traumatic brain injury: population-based study suggests increased risk of stroke. Stroke 2011; 42: 2733–39.

Mendez MF. What is the relationship of traumatic brain injury to dementia? J Alzheimers Dis 2017; 57: 667–81.

Williams WH, Chitsabesan P, Fazel S, et al. Traumatic brain injury: a potential cause of violent crime? Lancet Psychiatry 2018; 5: 836–44.

Fann JR, Ribe AR, Pedersen HS, et al. Long-term risk of dementia among people with traumatic brain injury in Denmark: a population-based observational cohort study. Lancet Psychiatry 2018; 5: 424–31.