Developmental disabilities among children younger than 5 years in 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016

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Summary

Background The Sustainable Development Goals (SDGs) mandate systematic monitoring of the health and wellbeing of all children to achieve optimal early childhood development. However, global epidemiological data on children with developmental disabilities are scarce. The Global Burden of Diseases, Injuries, and Risk Factors Study 2016 provides a comprehensive assessment of prevalence and years lived with disability (YLDs) for development disabilities among children younger than 5 years in 195 countries and territories from 1990 to 2016.

Methods We estimated prevalence and YLDs for epilepsy, intellectual disability, hearing loss, vision loss, autism spectrum disorder, and attention deficit hyperactivity disorder. YLDs were estimated as the product of the prevalence estimate and the disability weight for each mutually exclusive disorder, corrected for comorbidity. We used DisMod-MR 2.1, a Bayesian meta-regression tool, on a pool of primary data derived from systematic reviews of the literature, health surveys, hospital and claims databases, cohort studies, and disease-specific registries.

Findings Globally, 52·9 million (95% uncertainty interval [UI] 48·7–57·3; or 8·4% [7·7–9·1]) children younger than 5 years (54% males) had developmental disabilities in 2016 compared with 53·0 million (49·0–57·1; or 8·9% [8·2–9·5]) in 1990. About 95% of these children lived in low-income and middle-income countries. YLDs among these children increased from 3·8 million (95% UI 2·8–4·9) in 1990 to 3·9 million (2·9–5·2) in 2016. These disabilities accounted for 13·3% of the 29·3 million YLDs for all health conditions among children younger than 5 years in 2016. Vision loss was the most prevalent disability, followed by hearing loss, intellectual disability, and autism spectrum disorder. However, intellectual disability was the largest contributor to YLDs in both 1990 and 2016. Although the prevalence of developmental disabilities among children younger than 5 years decreased in all countries (except for North America) between 1990 and 2016, the number of children with developmental disabilities increased significantly in sub-Saharan Africa (71·3%) and in North Africa and the Middle East (7·6%). South Asia had the highest prevalence of children with developmental disabilities in 2016 and North America had the lowest.

Interpretation The global burden of developmental disabilities has not significantly improved since 1990, suggesting inadequate global attention on the developmental potential of children who survived childhood as a result of child survival programmes, particularly in sub-Saharan Africa and south Asia. The SDGs provide a framework for policy and action to address the needs of children with or at risk of developmental disabilities, particularly in resource-poor countries.

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Introduction Early childhood, commonly defined as the first 5 years of life, is the fastest period of growth and the period in which the developing brain is most sensitive to stimulation and nurturing. This period of development is regarded as the foundation for subsequent educational and vocational attainment at the individual level, and for overall human capital and economic development at the population level. The UN’s Millennium Development Goals (MDGs) focused largely on reducing under-5 mortality, especially in low-income and middle-income countries (LMICs). By contrast, the UN’s Sustainable Development Goals (SDGs) from 2015 to 2030 envision improvements in the broader health status of children beyond survival. Alongside the general recognition of people with disabilities in several of the SDGs, SDG 4 specifically requires actions to monitor the proportion of children younger than 5 years who are achieving their developmental potential in health, education, and psychosocial wellbeing, disaggregated by disability, age, sex, geographic location, and other characteristics. Developmental disabilities are a group of conditions resulting from impairments that affect a child’s physical, learning, or behavioural functioning. Affected children...
Research in context

Evidence before this study
Since 2007, The Lancet Series on early childhood development has provided estimates of children at risk of suboptimal development in low-income and middle-income countries (LMICs). However, similar to previous estimates, the most recent estimate of 250 million at-risk children, which was derived from 141 countries, is restricted to those who are stunted or exposed to extreme poverty in LMICs and excludes the vast majority of children with developmental delays and disabilities. More comprehensive baseline data that directly describe dimensions of health related to neurocognitive development are required for monitoring the proportion of children younger than 5 years who are at risk of suboptimal development in health, learning, and wellbeing as mandated by the UN’s Sustainable Development Goals (SDGs). The Global Burden of Diseases, Injuries, and Risk Factors Study 2016 (GBD 2016) produced comprehensive and comparable estimates of age-specific health disorders for 195 countries and territories from 1990 to 2016.

Added value of this study
This study reports GBD 2016 estimates of the prevalence and years lived with disability for developmental disabilities among children younger than 5 years, including epilepsy, intellectual disability, vision loss, hearing loss, autism spectrum disorder (ASD), and attention deficit hyperactivity disorder (ADHD). To our knowledge, this study is the first to investigate trends in the burden of these developmental disabilities between 1990 and 2016 and to provide baseline data for monitoring progress at the global, regional, and country levels under the SDGs.

Implications of all the available evidence
Although under-5 mortality halved between 1990 and 2016, there has not been a corresponding improvement in non-fatal health outcomes among childhood survivors globally. The number of children younger than 5 years at risk of suboptimal development in LMICs is likely to exceed 350 million (roughly three in every five children), even without inclusion of all known disabilities in GBD 2016. The absence of any systematic attention to developmental disabilities has had greatest effect in sub-Saharan Africa, where the number of affected children increased by more than 70% between 1990 and 2016, despite an overall decrease in prevalence worldwide during this period. The SDGs now present a comprehensive framework for addressing the burden of developmental delays and disabilities among survivors of the leading causes of child mortality in the early years of life, especially in LMICs. More crucially, local health and educational systems should be appropriately equipped to support affected children and their families optimally. Although the prevalence of conditions such as ASD and ADHD typically peak at school age or later, some children will require timely intervention from early childhood.

Global investment is needed to improve primary data sources for developmental disabilities to minimise uncertainty around the estimates of non-fatal health outcomes in most countries.

typically have sensory impairments (hearing and vision loss), epilepsy or seizures, cerebral palsy, attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD), intellectual disability, or other learning disorders. Children with developmental delays and disabilities are at greater risk of suboptimal health, educational attainment, and wellbeing than are children without such disabilities. However, epidemiological data on developmental disabilities to guide comprehensive health policy engagements at global, regional, and national levels are scarce. The most widely reported data to date suggest that roughly 250 million children are at risk of suboptimal development in LMICs. However, this number is based solely on children thought to be at risk of poor development because of stunting or extreme poverty and does not fully capture children with developmental disabilities. Another study based on UNICEF’s Early Childhood Development Index estimated that 80-8 million children aged 3 or 4 years in LMICs had low cognitive or socioemotional development in 2010. That study was limited by the age group considered and the scope of developmental disabilities addressed. The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) offers an independent source of robust age-specific data on non-fatal health outcomes. We aimed to estimate the prevalence of disability and years lived with disability (YLDs) among children younger than 5 years with developmental disabilities based on findings from GBD 2016. This analysis provides baseline data for monitoring the trends in these metrics over time among children younger than 5 years during the SDG era. Leading causes of specific developmental disabilities are also examined.

Methods

Overview
This study complies with Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) recommendations. An overview of the general modelling strategies for the non-fatal health outcomes of 328 diseases and conditions, as defined in International Classification of Diseases (ICD) codes 9 and 10, is provided in the appendix. Detailed descriptions of the modelling approaches for each of the four impairments (epilepsy, intellectual disability, hearing loss, and vision loss) and two GBD causes (ASD and ADHD) included in this report, along with specific data, diagnostic, and modelling considerations for each, are also provided in the appendix.

The causes included in estimation of each of the impairments are shown in the appendix. Although cerebral palsy was not estimated as a separate impairment, estimates of its prevalence and YLDs are included in
those of intellectual disability because of overlapping, cause-specific perinatal complications, including neonatal preterm birth complications, neonatal encephalopathy due to asphyxia and birth trauma, neonatal sepsis and other neonatal infections, and kernicterus after neonatal jaundice. We considered all developmental disorders or impairments as proxies for developmental disabilities in this study.

The two metrics, prevalence and YLDs, associated with developmental disorders in the GBD study are collectively referred to as the burden of disability in this study, without prejudice towards any ethical, sociocultural, or public health constructs of disability in the literature. Prevalence estimates are stated in both absolute numbers and per 100,000 children, in keeping with the practice for all conditions in the GBD study. The term disability is used to describe the perceived short-term or long-term loss of health (and not welfare loss) associated with a condition, which is reflected through an estimated disability weight. Thus, YLDs do not strictly measure disability from a public health perspective based on WHO’s International Classification of Functioning, Disability and Health (ICF). Rather, the metric seeks to provide a comparable measure of disease burden across diverse health conditions and impairments.

Case definitions and diagnostic criteria were based on ICD-9 and ICD-10 codes complemented with relevant guidelines, such as the Diagnostic and Statistical Manual of Mental Disorders (DSM)-IV-TR and the Guidelines for Epileptic Studies on Epilepsy. Developmental intellectual disability was separated into five bands based on intelligence quotient scores: borderline, mild, moderate, severe, and profound. Hearing and visual impairments were similarly separated into bands of severity corresponding to frequency response and visual acuity cutoffs, respectively. The age at which conditions such as ASD and ADHD could be diagnosed in early childhood was also considered in input data evaluation and model development.

Data sources and modelling strategy

The GBD estimation strategy is designed to provide a standardised analytical approach for estimating prevalence and YLDs by age, sex, cause, year, and location. The first step in the estimation of each condition was compilation of all available data inputs from systematic reviews of the literature, hospital and claims databases, health surveys, case notification systems, cohort studies, and multinational survey data. All input data for GBD 2016 are available at the Global Health Data Exchange. Effort was made to optimise the comparability of data derived from different sources using different methods, to find a consistent set of estimates across prevalence data, and to generate estimates for locations with sparse or no data by use of available information from other locations combined with covariates. We obtained prevalence estimates by age group from 1990 to 2016 using DisMod-MR 2.1, a statistical modelling, Bayesian meta-regression tool developed for the GBD project. DisMod-MR 2.1 synthesises epidemiological data for non-fatal health outcomes from disparate settings and sources, adjusting for different case definitions or diagnostic criteria and sampling methods to generate internally consistent estimates of prevalence, incidence, remission, and mortality by location, year, age group, and sex. Estimation in DisMod-MR 2.1 occurs sequentially at five levels: global, super-region, region, country, and subnational. Results from higher levels guide analyses at lower geographical levels. Model parameters, input data values, and fit statistics for each component model are viewable in the publicly available Epi Visualisation tool.

After generating internally consistent estimates of incidence, prevalence, remission, and mortality for each condition, prevalent cases were distributed among a set of mutually exclusive and collectively exhaustive sequelae (ie, severity of the disease state). The complete sequela list for each cause and impairment are provided in their corresponding methods description in the appendix. After initial calculation of sequela-level prevalence, GBD ensured that the sum of all causes leading to each impairment was scaled to equal the total number of cases of the impairment. Because of the commonality of co-occurrence of epilepsy, blindness, and intellectual disability arising from many causes (eg, neonatal complications leading to cerebral palsy, long-term complications of cerebral malaria and meningitis), scaling the prevalence sums of each impairment was done sequentially. After scaling, each sequel was paired with a unique health state describing the associated disability. Each health state had a corresponding disability weight that was estimated with pairwise comparison methods that presented pairs of lay health-state descriptions to more than 60,000 respondents in open web-based surveys done among the general population in nine countries (Bangladesh, Hungary, Indonesia, Italy, Peru, Sweden, Tanzania, the USA, and the Netherlands). Disability weights ranged between 0 (perfect health) and 1 (death), and were assumed to be similar in different locations. By contrast, the distribution of sequelae varied by location, year, sex, and age. Sequela-level prevalence estimates were multiplied by the disability weights to generate YLDs. YLDs for each sequel was then adjusted for comorbidity with a microsimulation framework that assumed that comorbidity within each age group, sex, location, and year was independent.

All computations in GBD were done 1000 times, each time drawing from the distribution of the sampling error of data inputs, the uncertainty of data corrections for measurement errors, the uncertainty in coefficients from model fit, and the uncertainty of severity distributions and disability weights. Uncertainty intervals (UIs) were defined by the 25th and 975th values of the ordered 1000 estimate values. Changes in estimates between locations or over time that were in the
| Region          | Number of cases 1990 | Cases per 100000 population | Number of YLDs 1990 | YLDs per 100000 population |
|-----------------|----------------------|------------------------------|---------------------|-----------------------------|
|                |                      |                              |                     |                             |
| Global          | 53 003 423           | 52 856 396                   | 3 755 596           | 3 941 530                   |
| High SDI        | 2 960 781            | 2 540 450                    | 224 493             | 179 389                     |
| High-middle SMI | 6 365 691            | 4 353 445                    | 457 376             | 355 258                     |
| Middle SMI      | 17 332 181           | 12 465 029                   | 1 180 392           | 879 242                     |
| Low-middle SMI  | 19 191 346           | 20 255 682                   | 1 404 464           | 1 574 971                   |
| Low SMI         | 7 070 383            | 12 439 791                   | 481 760             | 492 926                     |
| High income     | 2 905 208            | 2 694 277                    | 226 072             | 210 347                     |
| High-income     | 836 136              | 884 082                      | 27 660              | 74 837                      |
| North America   | (764 010 to 916 681) | (807 346 to 965 387)        | (53 004 to 96 191)  | (54 966 to 97 397)          |
| Canada          | 67 891               | 73 995                       | 5 437               | 5 821                       |
| Greenland       | 205                  | 137                          | 67 169              | 68 730                      |
| USA             | 766 633              | 809 661                      | 64 414              | 65 780                      |
| Australia       | 75 024               | 85 028                       | 38 940              | 25 990                      |
| New Zealand     | 13 969               | 14 023                       | 38 940              | 25 990                      |
| High-income Asia| 529 783              | 366 621                      | 302 227             | 240 753                     |
| Pacific         | (488 294 to 597 587) | (303 705 to 408 893)        | (289 751 to 392 679) | (263 262 to 364 481)       |
| Brunei          | 1 783                | 1 641                        | 131                 | 130                         |
| Japan           | 346 604              | 253 381                      | 24 440              | 17 776                      |
| Singapore       | 72 124               | 84 662                       | 12 287              | 5 992                       |
| South Korea     | 178 133              | 100 136                      | 37 843              | 25 846                      |
| Western Europe  | 1 171 283            | 1 082 083                    | 89 200              | 64 095                      |
| Andorra         | 109                  | 145                          | 8                  | 8                           |
| Austria         | 21 955               | 19 741                       | 12 044              | 17 776                      |
| Belgium         | 29 948               | 29 674                       | 24 440              | 17 776                      |
| Cyprus          | 315 472              | 270                          | 24 440              | 17 776                      |
| Denmark         | 10 307               | 991                          | 24 440              | 17 776                      |

(1Table continues on next page)
## Number of cases, Cases per 100,000 population, Number of YLDs, YLDs per 100,000 population

| Country          | 1990 | 2016 | 1990 | 2016 | 1990 | 2016 |
|------------------|------|------|------|------|------|------|
| Finland          | 14599 | 13533 | 47990.0 (4183.4 to 4652.4) | 4652.4 (4067.6 to 5156.9) | 1117 | 1040 |
| France           | 177256 | 17439 | 4850.0 (4198.4 to 4541.8) | 4449.8 (3995.7 to 4961.4) | 18422 | 14036 |
| Germany          | 253341 | 197394 | 5948.8 (5238.4 to 5755.6) | 5755.6 (5020.0 to 6471.5) | 38992 | 15773 |
| Greece           | 2432 | 20458 | 4622.7 (4042.8 to 4329.9) | 4329.9 (3771.3 to 4976.2) | 2062 | 1675 |
| Iceland          | 976 | 929 | 4501.1 (3982.1 to 4329.9) | 4329.9 (3807.2 to 4941.9) | 77 | 74 |
| Ireland          | 1512 | 1653 | 5149.6 (4653.9 to 4990.2) | 4990.2 (4714.6 to 5282.3) | 1139 | 1124 |
| Israel           | 33959 | 52288 | 5770.9 (6004.5 to 5742.1) | 6004.5 (5581.1 to 6563.6) | 2328 | 3563 |
| Italy            | 151853 | 137195 | 3598.4 (3605.6 to 3590.1) | 3590.1 (3604.1 to 3595.5) | 11120 | 10112 |
| Luxembourg       | 1206 | 1253 | 2589.9 (2612.1 to 2571.5) | 2612.1 (2536.3 to 2688.9) | 120 | 120 |
| Malta            | 15714 | 945 | 3497.1 (3931.3 to 3762.4) | 3931.3 (3427.6 to 4563.8) | 321 | 304 |
| Netherlands      | 10853 | 3719 | 4209.2 (3795.3 to 4628.4) | 4628.4 (4438.3 to 5013.5) | 965 | 990 |
| Norway           | 1178 | 1186 | 5412.1 (5061.1 to 5875.9) | 5061.1 (4857.9 to 5932.3) | 4427 | 3186 |
| Portugal         | 32308 | 25721 | 5708.0 (5094.9 to 6158.3) | 5094.9 (4568.9 to 5518.7) | 11172 | 11172 |
| Spain            | 117273 | 111272 | 4209.2 (3795.3 to 4628.4) | 4628.4 (4438.3 to 5013.5) | 11725 | 11172 |
| Sweden           | 2042 | 2156 | 3620.9 (3305.2 to 3957.7) | 3305.2 (3440.7 to 4124.8) | 1812 | 1812 |
| Switzerland      | 18184 | 18488 | 4652.1 (4360.5 to 4954.7) | 4360.5 (4376.1 to 5452.8) | 1421 | 1421 |
| UK               | 19620 | 21846 | 5003.8 (4653.2 to 5425.4) | 4653.2 (4260.0 to 5456.5) | 15333 | 14799 |
| Southern Latin America | 28198 | 27653 | 6202.9 (5086.3 to 7387.3) | 5086.3 (5204.2 to 6767.2) | 11270 | 11270 |
| Argentina        | 184545 | 18467 | 6202.9 (5086.3 to 7387.3) | 5086.3 (5204.2 to 6767.2) | 11270 | 11270 |
| Chile            | 8633 | 8630 | 6099.7 (5573.1 to 6673.3) | 5573.1 (5336.5 to 9250.9) | 12388 | 1288 |
| Uruguay          | 1522 | 1360 | 6099.7 (5573.1 to 6673.3) | 5573.1 (5336.5 to 9250.9) | 15333 | 14799 |
| Central Europe, eastern Europe, and central Asia | 268760 | 261623 | 7682.3 (7045.7 to 8361.5) | 7045.7 (6182.5 to 7756.2) | 168063 | 140511 |
| Eastern Europe   | 268760 | 261623 | 7682.3 (7045.7 to 8361.5) | 7045.7 (6182.5 to 7756.2) | 168063 | 140511 |
| Belarus          | 1194573 | 884720 | 8487.20 (6600.4 to 10290.2) | 6600.4 (5713.9 to 7940.8) | 84134 | 68463 |
| Estonia          | 57235 | 30575 | 6574.5 (6068.6 to 7048.7) | 6068.6 (5547.0 to 6675.3) | 3925 | 2697 |
| Latvia           | 14195 | 7089 | 5496.4 (5009.0 to 5966.4) | 5009.0 (4562.9 to 5468.6) | 584 | 285 |
| Lithuania        | 18474 | 8959 | 5717.1 (5620.3 to 5792.7) | 5620.3 (5205.8 to 6130.5) | 668 | 492 |
| Moldova          | 31188 | 31705 | 6399.0 (5760.1 to 6959.0) | 5760.1 (5332.5 to 6352.9) | 1372 | 712 |
| (Continued from previous page) | | | | | | |
| Articles |
| --- |
| **Number of cases** | **Cases per 100 000 population** | **Number of YLDs** | **YLDs per 100 000 population** |
| **1990** | **2016** | **1990** | **2016** | **1990** | **2016** |
| (Continued from previous page) | | | | | | |
| Russia | 839,843 | 658,551 | 7475.2 (6846.7 to 8132.6) | 7022.8 (6404.9 to 7631.4) | 57,189 | 11,843 (10,754 to 12,932) |
| Ukraine | 232,355 | 155,202 | 6557.9 (5971.8 to 7203.3) | 6119.4 (5421.7 to 6839.9) | 17,604 | 11,912 (10,728 to 13,095) |
| Central Europe | 707,126 | 385,463 | 7834.4 (7165.5 to 8582.4) | 6898.6 (6288.9 to 7506.9) | 44,850 | 24,733 (23266.3 to 25288.8) |
| Albania | 32,084 | 13,095 | 8125.6 (7052.2 to 9385.5) | 7066.8 (6136.0 to 8108.6) | 2214 | 909 (8210.3 to 10553.1) |
| Bosnia and Herzegovina | 34,545 | 12,961 | 9359.4 (8542.1 to 10264.3) | 9247.9 (8399.7 to 10247.9) | 2193 | 234 (1952.8 to 2864.7) |
| Bulgaria | 39,074 | 21,397 | 6021.4 (6070.3 to 7985.8) | 6432.8 (5932.5 to 7283.6) | 2574 | 1473 (1308 to 1626) |
| Croatia | 18,572 | 12,189 | 6335.4 (5732.9 to 6969.2) | 6195.4 (5610.9 to 6828.6) | 1347 | 867 (1282 to 1646) |
| Czech Republic | 37,910 | 20,709 | 5808.1 (5521.0 to 6741.4) | 5556.6 (5443.2 to 6178.9) | 2781 | 2187 (1950 to 2305.5) |
| Hungary | 38,486 | 26,618 | 6241.4 (5625.4 to 6890.4) | 5836.6 (5274.7 to 6619.3) | 805 | 517 (561 to 635) |
| Macedonia | 12,355 | 7497 | 7212.6 (6299.7 to 8233.8) | 6680.1 (5889.9 to 7546.8) | 244 | 165 (134 to 218) |
| Montenegro | 3577 | 2402 | 7021.9 (6151.9 to 7944.4) | 6933.5 (6077.5 to 7690.3) | 2049 | 244 (133 to 344) |
| Poland | 278,364 | 151,335 | 9635.9 (8390.1 to 10313.3) | 8909.4 (7459.1 to 8768.2) | 15,028 | 12586 (11072.4 to 14100.8) |
| Romania | 126,976 | 63,716 | 7156.0 (6280.0 to 8177.6) | 6495.6 (5945.5 to 7288.0) | 8665 | 5491 (6065 to 7189) |
| Serbia | 52,840 | 28,830 | 7430.3 (6524.5 to 8545.8) | 6966.8 (6094.0 to 7914.6) | 2904 | 2111 (2813 to 3433) |
| Slovakia | 24,732 | 16,215 | 5997.2 (5401.1 to 6642.7) | 5624.3 (5064.5 to 6282.9) | 1875 | 1266 (1142 to 1481) |
| Slovenia | 7262 | 6238 | 6699.7 (5512.9 to 7668.0) | 5893.1 (5259.8 to 6579.7) | 548 | 478 (388 to 575) |
| Central Asia | 785,920 | 741,440 | 8925.6 (7401.0 to 9190.1) | 7865.8 (7044.3 to 8537.4) | 51,660 | 51,922 (51,766 to 53,850) |
| Armenia | 33,654 | 16,595 | 8272.8 (7589.9 to 9028.1) | 7484.9 (6808.0 to 8236.5) | 2424 | 1224 (1170 to 1278) |
| Azerbaijan | 69,516 | 61,959 | 7919.5 (5714.2 to 8626.4) | 7314.6 (6495.2 to 8030.5) | 4634 | 4280 (3146 to 5489) |
| Georgia | 35,772 | 24,963 | 7784.8 (7075.2 to 8635.3) | 7491.8 (8280.0 to 8522.7) | 2513 | 1784 (1473 to 2114) |
| Kazakhstan | 152,581 | 142,514 | 7802.1 (7124.2 to 8652.8) | 7274.3 (6603.3 to 7971.1) | 10,433 | 10,201 (8799 to 12,471) |
| Kyrgyzstan | 51,009 | 46,924 | 8339.7 (7646.1 to 9093.5) | 8516.6 (7848.4 to 9040.9) | 3228 | 1419 (1235 to 1605) |
| Mongolia | 28,311 | 17,794 | 8662.6 (7930.6 to 9405.1) | 7326.7 (7051.9 to 8427.1) | 1804 | 1307 (1284 to 1431) |
| Tajikistan | 78,566 | 60,976 | 8023.9 (7167.6 to 8962.1) | 8266.2 (7292.9 to 9296.5) | 2502 | 2614 (2304 to 2906) |
| Turkmenistan | 46,283 | 43,835 | 8380.4 (7693.9 to 8911.8) | 7662.7 (6621.4 to 7977.4) | 2956 | 2929 (2803 to 3412) |
| Uzbekistan | 290,274 | 258,528 | 8761.4 (8005.4 to 8731.9) | 7833.7 (7078.0 to 8435.3) | 18,376 | 18,091 (13,182 to 24,661) |
| Latin America and Caribbean | 4,462,619 | 3,829,678 | 8474.1 (7836.5 to 9335.7) | 7720.4 (7118.3 to 8348.2) | 286,888 | 258,663 (210,941 to 314,042) |
| Central Latin America | 1,994,847 | 1,680,405 | 8196.6 (7545.8 to 8851.4) | 7356.7 (6547.6 to 8001.1) | 133,143 | 116,653 (83,529 to 154,377) |

(Table continues on next page)
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| Country          | 1990      | 2016      | 1990      | 2016      | 1990      | 2016      | 1990      | 2016      |
|------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| **Articles**     |           |           |           |           |           |           |           |           |
| **Total**        |           |           |           |           |           |           |           |           |
| **Cari**         |           |           |           |           |           |           |           |           |
| **Cari**         | 2013      | 2014      | 2015      | 2016      | 2017      | 2018      | 2019      | 2020      |
| **Nicaragua**    | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Bolivia**      | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Ecuador**      | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Peru**         | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Caribbean**    | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Antigua and**  |           |           |           |           |           |           |           |           |
| **Barbuda**      | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **The Bahamas**  | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Barbados**     | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Belize**       | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Bermuda**      | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Cuba**         | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Dominican**    | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Republic**     | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Grenada**      | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Guyana**       | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Haiti**        | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Jamaica**      | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Puerto Rico**  | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Saint Lucia**  | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |
| **Total**        | 577       | 577       | 577       | 577       | 577       | 577       | 577       | 577       |

Note: The table continues on the next page.
### Articles

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| Region            | Number of cases | 1990 | 2016 | Cases per 100 000 population | Number of YLDs | 1990 | 2016 | YLDs per 100 000 population |
|-------------------|----------------|------|------|-------------------------------|----------------|------|------|-------------------------------|
| Saint Vincent and the Grenadines | 1252 | 662  | 8051.2 (7455.4 to 8665.8) | 7243.1 (6621.3 to 7925.9) | 78   | 58   | 504.1 (358.4 to 679.9) |
| Suriname          | 4495 | 3348 | 7982.5 (7342.1 to 8684.0) | 7206.9 (6522.6 to 8056.6) | 376  | 322  | 668.5 (456.6 to 957.5) |
| Trinidad and Tobago | 10493 | 4535 | 7402.1 (6818.8 to 8043.1) | 6583.0 (6034.7 to 7176.2) | 832  | 517  | 586.6 (411.1 to 829.7) |
| Virgin Islands    | 719  | 333  | 6513.6 (5958.4 to 7108.4) | 6007.4 (5528.2 to 6411.7) | 53   | 478  | 482.8 (341.9 to 670.8) |
| Tropical Latin America | 1593751 | 128876.8 | 8490.4 (7838.6 to 9172.6) | 7990.0 (7393.4 to 8668.0) | 93146 | 79684 | 791.6 (5668.0 to 10534) |
| Brazil            | 1531450 | 1238091 | 8442.9 (7789.3 to 9124.8) | 7990.0 (7393.4 to 8668.0) | 93146 | 79684 | 791.6 (5668.0 to 10534) |
| Paraguay          | 62201 | (57275 to 67614) | 9584.9 (9095.8 to 9973.8) | 8034.7 (7323.8 to 8749.1) | 3638 | 3210 | 757.4 (4043.0 to 7881) |
| Southeast Asia, east Asia, and Oceania | 11264121 (12072972) | 8601788 | 7820.4 (7272.3 to 8371.5) | 6089.2 (6444.9 to 7547.3) | 873897 | 856929 | 520.6 (3885.6 to 6794) |
| East Asia         | 8343699 | 4337471 | 7241.5 (6912.8 to 7925.0) | 6711.1 (6147.5 to 7243.8) | 533524 | 270007 | 474.6 (352.9 to 626.5) |
| China             | 8023886 | 4026176 | 7439.3 (6922.1 to 7944.8) | 6654.0 (6019.8 to 7182.4) | 512291 | 251325 | 479.5 (354.4 to 628.1) |
| North Korea       | 217143 | 241183 | 7288.4 (6716.7 to 7868.5) | 8510.0 (7562.5 to 8735.3) | 13483 | 14798 | 592.0 (462.1 to 757.5) |
| Taiwan            | 1020670 | 60111 | 6464.9 (5939.3 to 6968.9) | 5927.7 (5411.8 to 6411.4) | 6750 | 3885 | 425.2 (293.0 to 580.2) |
| Southeast Asia    | 468943 | 4145551 | 8621.4 (7952.1 to 9356.6) | 7269.6 (6684.9 to 7871.7) | 344448 | 309202 | 614.9 (454.4 to 796.7) |
| Cambodia          | 126592 | 148013 | 1027.9 (9849.4 to 11813.5) | 7857.2 (6812.3 to 8988.0) | 8847 | 11443 | 718.9 (496.7 to 984.8) |
| Indonesia         | 171047 | 170735 | 8125.0 (7687.0 to 8721.3) | 7512.6 (6927.3 to 8111.9) | 117832 | 124155 | 573.5 (427.5 to 753.2) |
| Laos              | 49214 | 65585 | 7576.0 (6787.1 to 8428.5) | 5802.4 (5268.6 to 6485.8) | 3815 | 5665 | 586.5 (4042.2 to 811.2) |
| Malaysia          | 142813 | 121304 | 5842.4 (5212.8 to 6506.6) | 4747.4 (4191.4 to 5332.3) | 12101 | 10809 | 495.0 (335.2 to 657.9) |
| Maldives          | 1705 | 2007 | 8696.8 (7537.2 to 10261.5) | 6404.1 (5596.9 to 7551.4) | 121 | 997 | 666.1 (465.4 to 906.8) |
| Mauritius         | 7554 | 4054 | 7441.8 (6880.5 to 8322.9) | 6218.3 (5480.6 to 6833.4) | 593 | 341 | 584.5 (403.7 to 786.4) |
| Myanmar           | 489593 | 351772 | 10075.7 (9099.0 to 11173.8) | 7522.7 (6697.9 to 8409.7) | 41365 | 31317 | 851.3 (593.4 to 1129.4) |
| Philippines       | 965939 | 1014332 | (161701 to 391681) | 10947.8 (10110.5 to 11809.1) | 57927 | 63694 | 672.4 (467.6 to 921.3) |
| Sri Lanka         | 167720 | 110308 | 93880.8 (8473.4 to 10407.7) | 7289.0 (6602.5 to 8122.2) | 12536 | 8919 | 703.5 (498.6 to 950.4) |
| Seychelles        | 596 | 515 | 7272.6 (6299.0 to 8379.4) | 6162.8 (5335.9 to 7027.3) | 46 | 42 | 556.0 (389.6 to 777.7) |
| Thailand          | 454321 | 188335 | 7797.2 (6881.5 to 8852.1) | 6081.0 (5316.1 to 6872.1) | 38022 | 16331 | 652.5 (471.5 to 871.9) |
| Timor-Leste       | 11497 | 13017 | 10435.8 (9097.3 to 11935.0) | 7863.8 (6892.0 to 8909.9) | 777 | 957 | 705.0 (495.6 to 957.9) |

(Table continues on next page)
| Articles  | 1990 | 2016 |
|----------|------|------|
| America  | 518  | 655  |
| Asia     | 836  | 1028 |
| Australia| 111  | 134  |
| Europe   | 361  | 420  |
| Middle East | 208 | 259  |
| North Africa | 126 | 155  |
| Oceania  | 123  | 153  |

(Continued from previous page)

| Number of YLDs | YLDs per 100,000 population |
|----------------|-----------------------------|
| 2010 | 2016 |
| Vietnam | 555 | 395 |
| Oceania | 356 | 293 |
| America | 421 | 389 |
| Asia | 288 | 257 |
| Australia | 207 | 184 |
| Europe | 188 | 169 |
| Middle East | 155 | 139 |
| North Africa | 123 | 107 |

(Continued on next page)
### Articles

| Country       | Number of cases (1990) | Number of cases (2016) | Number of YLDs (1990) | Number of YLDs (2016) | YLDs per 100,000 population (1990) | YLDs per 100,000 population (2016) |
|---------------|------------------------|------------------------|-----------------------|-----------------------|--------------------------------------|--------------------------------------|
| **Palestine** | 40 687                 | 108 607                | 10 701 2 (9586 3 to 11 943 4) | 10 006 0 (8998 1 to 11 158 0) | 3374                                 | (2262 to 5303)                       |
| **Oman**      | 40 313                 | 34 938                 | 12 025 1 (10 650 5 to 13 796 5) | 7 880 6 (6895 6 to 9052 3) | 2281                                 | (1560 to 3099)                       |
| **Qatar**     | 4459                   | 9090                   | 8652 8 (7796 0 to 9517 1) | 7 342 1 (6622 3 to 8322 3) | 352                                  | (240 to 484)                         |
| **Saudi Arabia** | 333 444             | 200 029                | 11 124 1 (10 230 7 to 12 546 0) | 8 026 6 (7270 9 to 8968 7) | 26 820                               | (18 150 to 42 504)                   |
| **Sudan**     | 321 859                | 420 767                | 12 879 4 (11 466 5 to 14 878 5) | 10 034 0 (8840 6 to 11 455 2) | 22 244                               | (15 662 to 31 777)                   |
| **Syria**     | 220 906                | 151 805                | 10 682 9 (9402 3 to 12 585 3) | 8 591 1 (7581 6 to 9954 2) | 18 572                               | (12 812 to 28 116)                   |
| **Tunisia**   | 102 029                | 64 352                 | 9 444 7 (8557 9 to 10 554 3) | 7 712 1 (6827 6 to 8276 5) | 8 670                                 | (5793 to 13 887)                      |
| **Turkey**    | 595 743                | 466 481                | 9 201 4 (8459 5 to 9955 9) | 7 574 5 (6903 2 to 8258 2) | 43 903                               | (29 627 to 60 860)                   |
| **United Arab Emirates** | 28 079           | 7 1111                | 10 234 7 (9 082 1 to 11 735 1) | 8 720 3 (7 791 0 to 10 008 7) | 1974                                 | (1365 to 2820)                       |
| **Yemen**     | 332 058                | 548 381                | 15 391 3 (13 983 2 to 16 822 7) | 11 852 5 (10 705 3 to 12 971 6) | 23 569                               | (16 460 to 31 745)                   |
| **South Asia** | 15 723 355          | 15 047 176             | 10 388 4 (9 056 3 to 11 294 8) | 9 792 4 (8 997 9 to 10 641 4) | 11 583 100                           | (873 74 1 to 14 883 34)              |
| **Bangladesh**| 157 312                | 1 315 169              | 10 770 5 (9 782 1 to 11 726 3) | 9 178 1 (8 387 1 to 10 025 1) | 126 917                              | (91 041 to 167 567)                  |
| **Bhutan**    | 7 593                  | 5 082                  | 8 855 2 (7 998 0 to 9 080 8) | 7 352 5 (6 092 0 to 8 282 9) | 610                                  | (438 83 to 590 74)                   |
| **India**     | 12 051 742             | 11 560 118             | 10 524 7 (9 065 3 to 11 431 3) | 10 008 6 (9 379 5 to 11 195 6) | 870 624                              | (638 55 12 to 1 102 261)             |
| **Nepal**     | 285 403                | 312 510                | 9 139 0 (8 423 8 to 10 348 5) | 7 830 6 (6 907 0 to 8 780 6) | 21 581                               | (15 935 to 28 902)                   |
| **Pakistan**  | 1 805 489              | 1 848 638              | 9 457 3 (8 545 8 to 10 499 8) | 8 017 7 (7 136 7 to 8 899 9) | 138 577                              | (100 072 to 186 838)                 |
| **Sub-Saharan Africa** | 8 537 769       | 14 709 465             | 10 466 2 (9 527 7 to 11 362 0) | 9 393 7 (8 535 3 to 10 237 1) | 604 496                              | (450 993 to 787 667)                 |
| **Southern sub-Saharan Africa** | 616 444         | 769 223                | 9 410 3 (8 736 3 to 10 084 0) | 8 935 9 (8 275 1 to 9 621 4) | 46 467                               | (34 445 to 61 466)                   |
| **Botswana**  | 17 818                 | 21 217                 | 9 422 0 (8 676 3 to 10 201 3) | 8 044 7 (7 332 3 to 8 959 8) | 1 259                                 | (908 to 1661)                        |
| **Lesotho**   | 24 292                 | 24 288                 | 11 119 2 (10 185 0 to 12 076 4) | 9 405 9 (8 584 0 to 10 283 1) | 1 584                                 | (1144 to 2086)                       |
| **Nambia**    | 22 998                 | 28 555                 | 10 357 2 (9 567 4 to 11 147 6) | 8 579 2 (7 864 9 to 9 836 8) | 1 548                                 | (1100 to 2091)                       |
| **South Africa** | 393 368             | 453 111                | 10 406 6 (8 782 8 to 10 062 3) | 9 042 0 (8 046 8 to 9 966 2) | 3 508                                 | (22 845 to 40 246)                   |
| **Swaziland** | 13 345                 | 17 898                 | 10 010 0 (9 445 7 to 10 972 0) | 9 042 4 (8 300 6 to 9 758 5) | 880                                  | (628 to 1167)                        |
| **Zimbabwe**  | 144 634                | 223 253                | 8 991 8 (8 247 9 to 9 750 9) | 8 814 8 (8 013 1 to 9 658 7) | 10 332                               | (7405 to 14 095)                     |

(Table continues on next page)
| Country                  | 1990 | 2016 | 1990 | 2016 | 1990 | 2016 | 1990 | 2016 |
|-------------------------|------|------|------|------|------|------|------|------|
| Saharan Africa          |      |      |      |      |      |      |      |      |
| Benin                   | 90.62 | 177.24 | 10606.9 (9490.4) | 9276.1 (8442.2) | 11894.9 | 10353.8 | 19715.2 | 10341.1 |
| Cameroon                | 181.67 | 317.95 | 9061.6 (8088.4) | 8246.0 (7269.7) | 10215.7 | 9311.3 | 19876.4 | 9130.2 |
| Cape Verde              | 529.29 | 632.00 | 9196.8 (8213.8) | 7326.8 (6502.9) | 10281.2 | 9429.9 | 12348.0 | 10459.0 |
| Chad                    | 216.76 | 254.49 | 11115.3 | 9635.6 (8817.0) | 10590.0 | 10459.3 | 15688.5 | 10943.5 |
| Côte d'Ivoire           | 207.75 | 325.73 | 14422.8 (9362.0) | 9140.2 (8402.0) | 11313.7 | 9890.5 | 19924.5 | 11686.5 |
| The Gambia              | 18.056 | 32.28 | 9883.3 (8797.4) | 9065.7 (8044.1) | 11110.0 | 10070.6 | 19794.4 | 10600.3 |
| Ghana                   | 241.529 | 260.748 | 9922.7 (9162.4) | 8602.7 (7836.0) | 10289.2 | 9457.1 | 19187.1 | 11232.1 |
| Guinea                  | 94.070 | 209.362 | 10266.5 (9043.0) | 9534.9 (8341.9) | 1156.4 | 10461.0 | 20117.0 | 12565.2 |
| Guinea-Bissau           | 17.499 | 28.482 | 10452.7 (9294.0) | 9187.8 (8173.4) | 11751.9 | 10262.1 | 11214.1 | 10483.6 |
| Liberia                 | 42.443 | 67.948 | 10522.9 (9299.5) | 9522.0 (8471.2) | 11795.4 | 10685.8 | 20740.7 | 12912.8 |
| Mali                    | 251.015 | 286.21 | 9739.0 (8809.3) | 8400.7 (7582.8) | 10699.4 | 9769.0 | 18711.3 | 11267.2 |
| Mauritania              | 37.028 | 45.164 | 12612.9 | 10528.7 (9615.4) | 11714.8 | 10386.3 | 17014.1 | 10966.0 |
| Niger                   | 164.510 | 208.686 | 11235.9 | 9554.0 (8922.4) | 11822.7 | 10756.8 | 18741.3 | 11792.4 |
| Nigeria                 | 1476.143 | 1317.958 | 9795.6 (8740.7) | 8324.2 (7418.0) | 10880.0 | 9309.8 | 17566.6 | 144421.1 |
| São Tomé and Príncipe   | 1911 | 2857 | 9705.0 (8994.7) | 8580.1 (7634.8) | 10803.0 | 9181.8 | 19618.6 | 10669.1 |
| Senegal                 | 121.632 | 226.916 | 990.1 (9059.4) | 8926.7 (8111.1) | 10816.1 | 9783.1 | 18406.7 | 11695.6 |
| Sierra Leone            | 59.363 | 89.956 | 9925.1 (8817.2) | 8660.0 (7903.0) | 11517.8 | 9665.0 | 18180.6 | 10350.1 |
| Togo                    | 64.227 | 79.409 | 10178.3 (9946.4) | 9896.0 (7954.7) | 11816.0 | 9795.0 | 20146.6 | 11794.2 |
| Western sub-Saharan Africa | 3412.289 | 3091.032 | 1010.4 (9155.8) | 8902.8 (8042.9) | 11063.0 | 9765.0 | 24546.5 | 11794.2 |
| Burundi                 | 150.740 | 202.093 | 9941.4 (8811.8) | 9433.1 (8278.5) | 11237.5 | 10649.0 | 17624.3 | 10214.0 |
| Comoros                 | 805.43 | 980.64 | 12562.5 | 10569.1 (9655.9) | 11296.4 | 10569.9 | 19215.5 | 10649.2 |
| Djibouti                | 1106.00 | 1406.08 | 9843.0 (8688.3) | 8472.6 (7514.4) | 11213.5 | 9590.6 | 19378.1 | 10711.1 |
| Eritrea                 | 63.370 | 74.584 | 11217.2 (9945.9) | 9373.1 (8307.6) | 11276.3 | 10586.4 | 15406.5 | 10737.9 |

(Continued from previous page)
| Articles |
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### Table 1: Number and prevalence per 100,000 population of cases of developmental disability and of YLDs in children younger than 5 years globally and by SDI group, GBD region and super-region, country, and territory in 1990 and 2016

| Country | Number of cases | Number of cases per 100 | Number of YLDs | Number of YLDs per 100 |
|---------|----------------|-------------------------|----------------|------------------------|
|         | 1990           | 2016                    | 1990           | 2016                   |
| Ethiopia| 785,925        | 1,320,045               |                |                        |
|         | (711,534 to 862,410) | (1,197,956 to 1,453,318) |                |                        |
| Kenya  | 434,918        | 655,871                 |                |                        |
|         | (403,139 to 467,459) | (607,766 to 705,248) |                |                        |
| Madagascar | 228,772 | 371,618                |                |                        |
|         | (204,517 to 254,458) | (331,001 to 411,783) |                |                        |
| Malawi | 145,810        | 249,622                 |                |                        |
|         | (131,904 to 160,385) | (221,779 to 277,295) |                |                        |
| Mozambique | 259,337 | 479,221                |                |                        |
|         | (227,862 to 291,274) | (423,575 to 540,445) |                |                        |
| Rwanda | 134,537        | 162,254                 |                |                        |
|         | (128,423 to 165,157) | (143,807 to 181,097) |                |                        |
| Somalia | 106,460        | 134,702                 |                |                        |
|         | (87,943 to 113,534) | (118,979 to 151,229) |                |                        |
| South Sudan | 162,890 | 219,354                |                |                        |
|         | (144,861 to 182,314) | (228,816 to 256,600) |                |                        |
| Tanzania | 469,827 | 739,263                |                |                        |
|         | (416,077 to 537,009) | (653,871 to 824,299) |                |                        |
| Uganda | 345,183        | 613,715                 |                |                        |
|         | (301,327 to 393,407) | (537,984 to 687,875) |                |                        |
| Zambia | 142,646        | 224,384                 |                |                        |
|         | (130,778 to 154,927) | (202,238 to 245,931) |                |                        |
| Central sub-Saharan Africa | 1,230,698 | 2,755,934 |                |                        |
|         | (1,237,965 to 1,399,075) | (2,571,238 to 2,945,481) |                |                        |
| Angola | 311,714        | 575,427                 |                |                        |
|         | (292,300 to 313,133) | (535,751 to 614,576) |                |                        |
| Central African Republic | 66,308 | 103,693                |                |                        |
|         | (61,775 to 70,949) | (96,234 to 111,613) |                |                        |
| Congo (Brazzaville) | 50,729 | 70,001                |                |                        |
|         | (47,417 to 54,276) | (74,038 to 86,182) |                |                        |
| Democratic Republic of the Congo | 867,649 | 1,964,218 |                |                        |
|         | (810,350 to 922,155) | (1,827,979 to 2,103,721) |                |                        |
| Equatorial Guinea | 93,780 | 87,700                |                |                        |
|         | (87,620 to 101,013) | (80,811 to 94,200) |                |                        |
| Gabon | 15,459         | 23,825                  |                |                        |
|         | (14,396 to 16,580) | (21,949 to 25,891) |                |                        |

Data in parentheses are 95% uncertainty intervals. YLD—year lived with disability. SDI—Sociodemographic index. GBD—Global Burden of Disease.

**Table 1: Number and prevalence per 100,000 population of cases of developmental disability and of YLDs in children younger than 5 years globally and by SDI group, GBD region and super-region, country, and territory in 1990 and 2016.**

some direction in more than 950 of the 1000 samples were considered as significant. Final estimates for children younger than 5 years were compiled by summing the prevalence and YLD estimates in the first four GBD age groups: early neonatal (0–6 days), late neonatal (7–27 days), post-neonatal (28–364 days), and 1–4 years. The aggregate figures for each of the impairments are independent from one another so the total burden from all developmental impairments is somewhat less than the sum of each impairment because of comorbidities.

**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**

**Global trend in prevalence and YLDs of developmental disabilities**

The estimated global number of children younger than 5 years in GBD 2016 was 598·5 million in 1990, 600·2 million in 2005, 626·9 million in 2010, and 632·0 million in 2016. The total number of children with any of the six developmental disabilities after adjusting for comorbidity between intellectual disability and ASD was 53·0 million (95% UI 49·0–57·1 [8·9%, 8·2–9·5%]) in 1990 compared with 52·9 million (48·7–57·3 [8·4%, 7·7–9·1%]) in 2016. Of the children with developmental disabilities in 2016, 2·7 million (5·1%) lived in high-income countries and 50·2 million (94·9%) in LMICs (table 1). About 54% of children with any developmental disability were male, although the proportions of male and female children varied by type of impairment.

Vision loss was the most prevalent developmental disability and decreased from 1990 to 2016 (figure 1). 26·4 million (95% UI 24·0–29·2) children had vision loss in 1990, corresponding to a prevalence of 4407 (95% UI 4006–4887) per 100 000 children. This figure declined to 25·2 million (22·7–28·4) in 2016, corresponding to a prevalence of 3991 (3595–4487) per 100 000 children. Hearing loss was the second most prevalent disability, affecting 15·0 million (13·0–17·1) children (prevalence 2511 [95% UI 2178–2859] per 100 000) in 1990. Although the prevalence of hearing loss decreased to 2445 (95% UI 2113–2793) per 100 000 children in 2016, the number of affected children increased slightly to 15·5 million (95% UI 13·4–17·7). ADHD was the least prevalent disability during the period, but increased from 835·171 (746·061–946·713) affected children in 1990 to 890·229 (794·104–1022·157) in 2016. Intellectual disability was associated with the highest YLDs throughout the period, followed by epilepsy, hearing loss, vision loss, ASD, and ADHD (figure 1). Compared with the estimates in 1990, the YLDs for intellectual disability and epilepsy increased in 2016, whereas the YLDs for hearing loss showed a steady but modest decline up to 2016. Generally, the UIs for the YLDs were wider than those for prevalence (figure 1).

Although the prevalence of developmental disabilities in children younger than 5 years declined from 1990 to 2006 in all regions except North America, the number of affected children increased by 71·3% in sub-Saharan Africa, 7·6% in north Africa and the Middle East, and 5·9% in North America (figure 2, table 1). These increases were offset globally by a decline in the number of children with disabilities in all other regions during this period, with southeast Asia, east Asia, and Oceania recording the largest decline of 34·5%. The six disabilities accounted for 3·8 million (95% UI 2·8–4·9) YLDs in 1990 compared with 3·9 million (2·9–5·2) in 2016 (table 1), representing 13·3% of the total 29·3 million (20·7–39·8) YLDs from all causes in children younger than 5 years in 2016. Sub-Saharan Africa recorded the highest increase in YLDs (91·1%), whereas southeast Asia, east Asia, and Oceania recorded the greatest decrease (–32·8%; figure 2).

**Regional and national prevalence of developmental disabilities in 2016**

The geographical distribution of developmental disabilities in 2016 based on prevalence estimates is shown in figure 3. Unlike most developmental disabilities, ASD was least prevalent in western Europe and ADHD in south Asia. The highest number of children with intellectual disability (3·9 million [95% UI 3·1–4·7]), hearing loss (5·1 million [4·4–5·8]), and ASD (1·2 million [1·0–1·4]) were recorded in south Asia (table 2), accounting for 31·1%, 32·9%, and 25·4% of the global prevalence, respectively. The highest number of children with epilepsy (1·2 million [0·8–1·7]), vision loss (6·9 million [6·2–7·8]), and ADHD (284·197 [251·986–325·635]) were recorded in sub-Saharan Africa, representing 30·4%, 27·5%, and 31·9% of the global prevalence, respectively. The
prevalence per 100 000 children of intellectual disability (2567 [95% UI 2099–3189]), vision loss (4947 [4324–5803]), and ASD (785 [645–948]) were highest in north Africa and the Middle East. Epilepsy, hearing loss, and vision loss were least prevalent in North America, whereas intellectual disability was least prevalent in Latin America. The highest prevalence of children with all disabilities was recorded in south Asia (9792 [8940–10 641] per 100 000) and the lowest in North America (4090 [3735–4467] per 100 000; table 1).

Country-specific prevalence estimates for each disability are presented in the appendix. For all disabilities, India had the highest number of affected children, except for ADHD, for which the highest number of affected children was in China (table 3). On the African continent, Nigeria, Democratic Republic of the Congo, and Ethiopia were among the top ten countries with the highest number of children with any disability. The USA was one of the top ten countries for intellectual disability, hearing loss, ASD, and ADHD. The highest prevalence of each disability was found in LMICs, apart from ASD and ADHD, which were highest in Sweden and Australia. The top ten countries accounted for more than half of the global prevalence of all developmental disabilities except for ADHD (48·2%; table 3).

Leading causes of developmental disabilities in 2016

The underlying causes of the four disorders conceptually modelled as impairments in GBD 2016 are presented in the appendix. Refraction and accommodation disorders (85·2%) were the leading cause of vision loss globally. The major causes of hearing loss were otitis media (57·1%) and congenital anomalies (21·1%). Congenital anomalies (39·7%) and neonatal disorders, including preterm birth complications, infections, and birth asphyxia (21·0%), were the prominent known causes of intellectual disability, whereas idiopathic causes accounted for 29·0%. Neonatal disorders (51·8%) were the leading cause of epilepsy. The extent to which these causes contributed to each impairment varied across the regions and by country.

Discussion

About 52·9 million (8·4%) children worldwide had one of the six developmental disabilities investigated by the GBD group in 2016 compared with 53·0 million (8·9%) in 1990. This marginal change is in sharp contrast with the trend in under-5 mortality, which substantially declined from 11 million (95% UI 10·8–11·3) in 1990 to 5 million (4·8–5·2) in 2016.14 The disproportionately high burden of development disabilities in LMICs has been corroborated by a 2018 systematic review.21 The increasing burden reflects the absence of any systematic global initiative to curtail this burden among the increasing number of children who are surviving the
first 5 years of life. It is likely that improving neonatal survival rates, particularly for those born prematurely, is contributing substantially to this burden, especially during the MDG era.

As with most health conditions, the dearth of population-based data for developmental disabilities, especially in LMICs, has led to a reliance on statistical estimation of trends in health outcomes to guide health

Figure 3: Global prevalence per 100 000 population of developmental disabilities among children younger than 5 years in 2016

A Epilepsy
B Developmental intellectual disability
C Hearing loss
D Vision loss
E Autism spectrum disorder
F Attention deficit hyperactivity disorder
| Region                                  | 5-Year Prevalence 2011-2015 (Per 100,000) | YLDs 2011-2015 | 5-Year Prevalence 2016 (Per 100,000) | YLDs 2016 |
|----------------------------------------|------------------------------------------|----------------|-------------------------------------|-----------|
| High-income North America              | 32.6% (15.9 to 60.1)                     | 2.6 (1.4 to 3.6) | 30.7% (15.2 to 58.8)                | 2.5 (1.4 to 3.3) |
| Western Europe                         | 41.8% (25.9 to 58.1)                     | 23.3 (15.5 to 30.7) | 41.2% (25.0 to 56.3)                | 22.8 (15.4 to 30.1) |
| Central Europe, eastern Europe, and central Asia | 35.7% (24.1 to 50.3)                     | 20.4 (14.0 to 27.0) | 35.4% (23.7 to 50.8)                | 20.1 (14.0 to 26.9) |
| Latin America and Caribbean            | 35.2% (22.4 to 49.3)                     | 16.3 (11.6 to 21.2) | 34.9% (22.3 to 48.7)                | 16.1 (11.5 to 20.8) |
| Southeast Asia, east Asia, and Oceania | 35.2% (22.4 to 49.3)                     | 16.3 (11.6 to 21.2) | 34.9% (22.3 to 48.7)                | 16.1 (11.5 to 20.8) |
| South Asia                             | 35.7% (24.1 to 50.3)                     | 20.4 (14.0 to 27.0) | 35.4% (23.7 to 50.8)                | 20.1 (14.0 to 26.9) |
| Sub-Saharan Africa                     | 41.2% (25.0 to 56.3)                     | 22.8 (15.4 to 30.1) | 41.4% (24.9 to 57.7)                | 22.9 (15.5 to 30.4) |
### Table 2: Global and regional prevalence of developmental disabilities and YLDs among children younger than 5 years in 2016

| Condition          | Cases | YLDs  |
|--------------------|-------|-------|
| **Epilepsy**       |       |       |
| North Africa and Middle East | Cases | YLDs  |
| Number in 2016     | 458,924 | (321,791 to 815,593) |
| Per 100,000 population | 276 | (109 to 1,291) |
| **Intellectual disability** |       |       |
| Global             | 3,089,557 | 1,648,478 |
| Per 100,000 population | 603 | (479 to 823) |
| **Hearing loss**   |       |       |
| North Africa and Middle East | Cases | YLDs  |
| Number in 2016     | 162,298 | (126,628 to 215,668) |
| Per 100,000 population | 299 | (186 to 578) |
| **Vision loss**    |       |       |
| North Africa and Middle East | Cases | YLDs  |
| Number in 2016     | 132,343 | (114,347 to 154,438) |
| Per 100,000 population | 267 | (9 to 578) |
| **ASD**            |       |       |
| North Africa and Middle East | Cases | YLDs  |
| Number in 2016     | 128,567 | (109,306 to 147,606) |
| Per 100,000 population | 104 | (78 to 227) |
| **ADHD**           |       |       |
| North Africa and Middle East | Cases | YLDs  |
| Number in 2016     | 10,948 | (8,734 to 14,984) |
| Per 100,000 population | 86 | (57 to 148) |

Data in parentheses are 95% uncertainty intervals unless otherwise stated. ASD = autism spectrum disorder. ADHD = attention deficit hyperactivity disorder. YLD = years lived with disability.

Summary global estimates often mask significant variations at the regional and national levels. Although minimal decline was observed globally, the burden of all developmental disabilities is higher in males than in females for most developmental disabilities such as idiopathic cerebral palsy and other motor disorders from the study. However, it is possible that the estimate includes neither separate estimates of cerebral palsy nor quantification of the role of home life and child rearing patterns in the development of these disabilities. This study suggests that the burden of childhood development is higher in males than in females for most developmental disabilities. Although hearing and vision loss were the most prevalent developmental disabilities, the burden of epilepsy was higher in males than in females for most developmental disabilities. Recognition of the need for comprehensive early detection and intervention for all children with or at risk of any developmental disabilities, especially girls, is crucial. Early detection and intervention are crucial for improving outcomes and delaying and mitigating the effects of developmental disabilities. Early detection and intervention are crucial for improving outcomes and delaying and mitigating the effects of developmental disabilities. Early detection and intervention are crucial for improving outcomes and delaying and mitigating the effects of developmental disabilities. Early detection and intervention are crucial for improving outcomes and delaying and mitigating the effects of developmental disabilities. Early detection and intervention are crucial for improving outcomes and delaying and mitigating the effects of developmental disabilities. 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substantially increased in sub-Saharan Africa and in north Africa and the Middle East. Moreover, south Asia and sub-Saharan Africa, which frequently account for the highest child mortality globally, had the highest number of children with developmental disabilities, although south Asia showed some modest progress. This finding is consistent with other reports on the risk of suboptimal development among children younger than 5 years.10–12 For example, regardless of the differences in case definition, India, China, and Nigeria were the three leading countries with the highest number of children with or at risk of developmental disabilities. In 2016, Democratic Republic of the Congo displaced Nigeria from the third position for vision loss. Except for the USA, China, and Brazil, the ten leading countries for developmental disabilities were predominantly from south Asia and sub-Saharan Africa. This pattern of disease burden exemplifies the ethical rationale of the disability-inclusive framework of the SDGs that seeks to promote and ensure safety nets for the survivors of acute childhood illnesses in LMICs to set them on the trajectory of optimal early childhood development.

| Epilepsy | Intellectual disability | Hearing loss | Vision loss | Autism spectrum disorder | ADHD |
|----------|-------------------------|--------------|-------------|--------------------------|------|
| **Cases** | **YLDs** | **Cases** | **YLDs** | **Cases** | **YLDs** | **Cases** | **YLDs** | **Cases** | **YLDs** | **Cases** | **YLDs** |
| 1 | India | India | India | India | India | India | India | India | India | India |
| 2 | China | Nigeria | China | Nigeria | China | China | Nigeria | China | China | China |
| 3 | Nigeria | China | Nigeria | China | Nigeria | Nigeria | DR Congo | China | Nigeria | Nigeria |
| 4 | Pakistan | Pakistan | Pakistan | Pakistan | Bangladesh | Nigeria | Pakistan | Pakistan | Nigeria | Nigeria |
| 5 | Indonesia | Ethiopia | DR Congo | Ethiopia | Bangladesh | Pakistan | Indonesia | Ethiopia | Indonesia | Indonesia |
| 6 | Ethiopia | Indonesia | Ethiopia | DR Congo | DR Congo | Brazil | DR Congo | USA | USA | USA |
| 7 | Egypt | Egypt | Egypt | Egypt | Indonesia | Ethiopia | Pakistan | Egypt | Ethiopia | Brazil |
| 8 | DR Congo | DR Congo | USA | Indonesia | Ethiopia | Indonesia | Philippines | Iraq | Brazil | Brazil |
| 9 | Bangladesh | Iraq | Indonesia | USA | Brazil | Brazil | Egypt | Indonesia | Bangladesh | Bangladesh |
| 10 | Tanzania | Tanzania | Bangladesh | Iraq | USA | Philippines | Egypt | Indonesia | Bangladesh | DR Congo |

**Ranking by number in 2016**

**Top 10 total (proportion of global)***

| Rank | Country | Country | Country | Country | YLDs | YLDs | YLDs | YLDs | YLDs | YLDs |
|------|---------|---------|---------|---------|------|------|------|------|------|------|
| 1 | India | India | India | India | 233 | 52% | 52% |
| 2 | China | Nigeria | China | Nigeria | 198 | 52% | 52% |
| 3 | Nigeria | China | Nigeria | China | 183 | 52% | 52% |
| 4 | Pakistan | Pakistan | Pakistan | Pakistan | 179 | 52% | 52% |
| 5 | Indonesia | Ethiopia | DR Congo | Ethiopia | 158 | 52% | 52% |
| 6 | Ethiopia | Indonesia | Ethiopia | DR Congo | 152 | 52% | 52% |
| 7 | Egypt | Egypt | Egypt | Egypt | 149 | 52% | 52% |
| 8 | DR Congo | DR Congo | USA | Indonesia | 134 | 52% | 52% |
| 9 | Bangladesh | Iraq | Indonesia | USA | 131 | 52% | 52% |
| 10 | Tanzania | Tanzania | Bangladesh | Iraq | 129 | 52% | 52% |

**Ranking per 100,000 population**

| Rank | Country | Country | Country | Country | Country | Country | Country | Country | Country | Country |
|------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 1 | Mauritania | Dominican Republic | Afghanistan | Dominican Republic | Bangladesh | Yemen | DR Congo | Dominican Republic | Sweden | Australia |
| 2 | Dominican Republic | Iraq | Yemen | Iraq | Bangladesh | Yemen | DR Congo | Iraq | Iran | Sweden |
| 3 | Iraq | Mauritania | Sudan | Afghanistan | DR Congo | DR Congo | Angola | Suriname | Syria | Japan |
| 4 | Ghana | Ghana | Niger | Palestine | Central African Republic | Central African Republic | Afghanistan | Guyana | Saudi Arabia | New Zealand |
| 5 | Kenya | São Tomé and Príncipe | Liberia | Suriname | Kenya | Madagascar | Iraq | Palestine | Libya | Canada |
| 6 | São Tomé and Príncipe | Kenya | Central African Republic | Dominica | Bhutan | Kenya | South Sudan | Dominica | Kuwait | Singapore |
| 7 | Cape Verde | Suriname | Somalia | The Gambia | Entreatia | Madagascar | Pakistan | Angola | Mauritania | Gabon |
| 8 | The Gambia | Suriname | Somalia | The Gambia | Entreatia | Madagascar | Pakistan | South Africa | Mauritania | Congo (Brazzaville) |
| 9 | Senegal | Senegal | DR Congo | Guyana | Angola | Somalia | Egypt | Egypt | Jordan | Iran |
| 10 | Eritrea | Guyana | Palestine | Sudan | India | Burundi | Comoros | Afghanistan | Lebanon | Kuwait |

ADHD=attention deficit hyperactivity disorder. YLD=years lived with disability. *Percentages indicate proportions of the global count that are accounted for by the top ten countries.

Table 3: Top ten countries with specific developmental disabilities in children younger than 5 years in 2016
leading countries by actual number of children. Population-based data in some high-income countries, such as the USA, in fact show significant increasing trends in the prevalence of most developmental disabilities due in part to increases in the diagnosis and recognition of developmental disorders such as ASD and ADHD.24–27 This trend is consistent with the observed increases in the overall burden of developmental disabilities between 1990 and 2016 in North America. Moreover, the prevalence of all disabilities in the USA in GBD 2016 (4.1%, 95% UI 3.8–4.5) is comparable to the 5–2% reported among children younger than 6 years in the study by Houtrow and colleagues.28 The low prevalence of ADHD that we found globally compared with other disabilities could be partly attributable to the fact that no incidence was assumed before age 2 years in our modelling strategy (appendix). Also, except for severely affected children, the onset of ASD symptoms typically occurs by age 3 years, but may not fully manifest until school age or later.29 Additional information about the GBD method for identification and classification of ASD, which is applicable to ADHD, can be found in an earlier report by Baxter and colleagues.30 Although the GBD estimates are quite conservative, our findings underscore the need for intervention in some infants with ASD and ADHD from early childhood.

Identification of the major causes, as well as the effects, of developmental disabilities should be an urgent priority in regions with the largest prevalence and absolute burden for several reasons.31,32,33 First, most of the countries in those regions lack functional health-care and social-care systems to support children with disabilities. Second, the lifetime costs of supporting children with disabilities are substantial and might further impoverish many poor families and communities. Third, societal stigma and unfavourable cultural beliefs place children at great risk of neglect, violence, or even infanticide. Fourth, educational and vocational opportunities are limited and rarely allow full economic participation and independence of children with developmental disabilities when they transition into adulthood. A range of interventions for children with or at risk of developmental disabilities are well described in the literature,34–36 and include primary prevention aimed at reducing the incidence of developmental disabilities, secondary prevention through early detection of disabilities at a time when the brain is still very sensitive to interventions and change, and tertiary prevention through comprehensive community-based rehabilitation programmes (now termed community-based inclusive development), as exemplified by some early childhood development initiatives in high-burden LMICs such as Bangladesh and India.37,38 Some disabilities might be less amenable than others to prevention. For example, the GBD study did not investigate the causes of ASD and ADHD, which are often attributed to complex interactions between genetic and environmental factors.22 However, several risk factors amenable to intervention have been reported in the literature and merit attention and efforts to equip local health and educational systems to provide requisite services for the affected children and their families.39 The newly launched Nurturing Care Framework for Early Childhood Development by WHO and its partners to facilitate optimal early childhood development in LMICs40 should necessarily also prioritise actions to address the specific needs of children with or at risk of developmental disabilities under the SDG era, especially in nations with a high burden.13 A cursory or symbolic reference to developmental disabilities in this framework will not be adequate or effective in galvanising the required attention by policy makers for the affected children and their families.

The disability-inclusive aspirations of the SDGs agenda are reinforced by the UN’s Conventions on the Rights of the Child and the Rights of Persons with Disabilities. Since 2016, the GBD study has introduced a component for monitoring health-related targets and indicators periodically under the SDGs. Presently, 50 health-related indicators that directly involve health services, health outcomes, and risk factors with well established causal links have been identified, of which 37 are monitored in GBD 2016.41 Children with developmental disabilities are not yet captured within this framework because SDG 4 (to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all) is completely omitted from the considered health-related indicators. Moreover, developmental disabilities have not yet been explicitly linked with SDG 3, which seeks to ensure healthy lives and promote wellbeing at all ages. It is hoped that the growing evidence on health-related causes of developmental disabilities reported in this study, and elsewhere, will facilitate the development of specific and explicit health-related indicators to address the special needs of the affected children.42,43

Similar to any modelling endeavour in epidemiology, GBD 2016 has limitations that have been extensively described elsewhere in line with the GATHER reporting guidelines.44,45 For example, most of the uncertainty in the YLD estimates are likely to result from limitations in the calculations of disability weights. These uncertainties might be minimised in the future by removing some of the ambiguities in lay descriptions, providing better definitions for disorders in surveys, and increasing the general volume and quality of survey data in this area. Additionally, the non-fatal models, especially for conditions such as ASD and ADHD, continue to rely on sparse data in many regions and exemplify the unique challenges associated with measuring disability in childhood, particularly for more subtle and difficult to diagnose conditions such as ASD and ADHD.44–46 Ultimately, a measure of functional limitations consistent with ICF is
needed to complement the YLDs for developmental disabilities in childhood.

Additional limitations of this study deserve mention. First, direct and separate prevalence and YLDs estimates for other disabilities, such as cerebral palsy, communication, and motor disorders, were not provided, which will have resulted in underestimation of the overall number of children with developmental disabilities. There is no evidence to suggest, for example, that there has been any improvement in the global burden of cerebral palsy between 1990 and 2016. Second, age-standardised prevalence estimates and severity patterns of impairments were not reported in this analysis but are freely available at the Global Health Data Exchange for download and interactive visualisation for all the 195 countries and territories in GBD 2016. Third, we did not estimate the incidence of developmental delays and disabilities. Finally, it was difficult to completely and precisely account for children with multiple disabilities and across multiple developmental domains. These overlaps were partially captured by estimation of prevalence of sequelae (most children with ASD also have intellectual disability), ensuring the total number of cases of each impairment equals the sum across all GBD causes, and accounting for the overlap between epilepsy, blindness, and intellectual disability. Therefore, the sum of the impairments and causes is not equal to the total number of children with developmental disability. Some residual overlap is certainly likely, however, especially for hearing and vision loss. We believe that the findings in the GBD study provide valuable baseline data for action and further refinements as more and better primary input sources become available for all developmental disabilities. This viewpoint is without prejudice to other ICF-oriented approaches to quantifying the actual burden of developmental disabilities at the family and societal levels. The annual updating of GBD allows for expedient incorporation of such insights and data as they become available. Additionally, because future GBD iterations will continue to refine the methods, incorporate new data sources, and reanalyse the entire time series, our estimates for 1990–2016 might not be identical to those in subsequent GBD reports.

In conclusion, although the burden of mortality among children younger than 5 years has been halved between 1990 and 2016, there has been no corresponding improvement in non-fatality health outcomes among children with developmental disabilities globally. This lack of improvement might be attributed to absent or inadequate systematic policies and interventions to address the needs of survivors of childhood illnesses who develop life-long disabilities from early childhood, especially in sub-Saharan Africa. This report underscores the importance of developing explicit health-related indicators for monitoring progress to address the needs and rights of children with or at risk of developmental disabilities within the framework of the disability-inclusive mandates of the SDGs and beyond. More crucially, local health and educational systems should be appropriately equipped to support affected children and their families optimally.

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Contributors
BOO, DW, JOO, HEO, NJK, and ACD conceived the study and provided overall guidance. HM, AS, ME, CI, AL, AM, KB, HEO, HEI, DS, HAW, ZR, MS, EN, and NJK applied the analytical methods to produce estimates. ACD, NH, MG, FAO, and JOO provided data or critical feedback on data sources. BOO, HK, FAO, and JOO wrote the first draft of the manuscript. NYB, CB, ACD, PJdV, MG, NH, RH, VK, HK, MCM, AK-M, MRCN, DW, ANW, and SMF provided critical feedback on the methods or results and critically reviewed the draft for important intellectual content. All authors read and approved the final draft for submission.

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