Global Burden of Stroke

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Abstract

Stroke is the second leading cause of death and a major cause of disability worldwide. Its incidence is increasing because the population ages. In addition, more young people are affected by stroke in low- and middle-income countries. Ischemic stroke is more frequent but hemorrhagic stroke is responsible for more deaths and disability-adjusted life-years lost. Incidence and mortality of stroke differ between countries, geographical regions, and ethnic groups. In high-income countries mainly, improvements in prevention, acute treatment, and neurorehabilitation have led to a substantial decrease in the burden of stroke over the past 30 years. This article reviews the epidemiological and clinical data concerning stroke incidence and burden around the globe.

Keywords
- stroke
- burden
- global
- epidemiology

Global Stroke Mortality, Disability, and Costs

Mortality

The latest estimate from the Global Burden of Disease, Injuries, and Risk Factors Study (GBD 2015) revealed a further shift from communicable diseases, maternal, and nutritional causes toward noncommunicable diseases like stroke. This effect is likely caused by an increase and aging of the world's population as well as by decreased death rates globally in recent decades.[1] The most prominent causes of death are vascular in nature, and stroke is currently the second leading cause of death worldwide.[2] Ischemic heart disease and stroke together accounted for 15.2 million deaths (15–15.6 million) in 2015.[2] While ischemic strokes comprise the highest number of stroke, much of the global burden of stroke measured in proportion to mortality and by mortality and disability-adjusted life-years (DALYs) is allocated to hemorrhagic stroke.[3] Low- and middle-income countries endure an 80% mortality rate with hemorrhagic stroke.[3]

Disability

Stroke is one of the leading causes of long-term disability in the United States, especially in the elderly population in which stroke incidence is highest. From the 795,000 new sufferers of stroke, 26% remain disabled in basic activities of daily living (Framingham cohort) and 50% have reduced mobility due to hemiparesis.[4] Aphasia and depression are other frequent causes of disability.[4] In comparison to other causes of DALYs in the world, stroke was the second largest contributor after ischemic heart disease globally and in developing countries, and the third largest contributor to DALYs in developed countries (after ischemic heart disease and lower back and neck pain), with significant regional variation in disease burden across both developed and low- to middle-income countries.[5] Stroke is preventable to a large extent due to modifiable risk factors.[6] Targeting risk factors such as high blood pressure, smoking, obesity, diabetes mellitus, atrial fibrillation, dyslipidemia, and lack of physical activity may have already contributed to the observed improvement of stroke incidence and DALYs in high-income countries over the last two decades. However, the absolute numbers of incident stroke, survivors, and stroke-related death as well as DALYs has globally increased (►**Table 1**), partly due to the rising numbers in low- and middle-income countries.[2] Moreover, an increase in stroke incidence and DALYs in adults aged 20 to 64 years has been observed. This increase was also most prevalent in developing countries, and due to hemorrhagic more than ischemic stroke.[7]

Costs

Currently, approximately 3 to 4% of total health care expenditures in Western countries are spent on stroke.[8] The mean

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Table 1 Absolute number of DALYs, deaths, incident, and prevalent cases of ischemic and hemorrhagic stroke (with 95% uncertainty intervals [UIs]) in the world in 1990 and 2013[5]

Parameter	1990	2013
Ischemic stroke		
Deaths	2,182,865 (1,923,290–2,430,872)	3,272,924 (2,812,654–3,592,562)
Incidence	4,309,356 (4,118,103–4,531,909)	6,892,857 (6,549,814–7,352,226)
Prevalence	10,045,202 (9,643,525–10,453,439)	18,305,491 (17,767,372–18,920,736)
DALYs	34,155,606 (29,592,196–38,325,866)	47,424,681 (40,537,540–52,211,800)
Hemorrhagic stroke		
Deaths	2,401,930.40 (2,109,380.2–2,669,117.5)	3,173,951 (2,885,717–3,719,684)
Incidence	1,886,345 (1,816,991–1,976,659)	3,366,175 (3,199,978–3,543,213)
Prevalence	3,891,158 (3,769,541–4,019,014)	7,363,457 (7,139,691–7,616,146)
DALYs	55,953,376 (49,881,127–62,161,971)	65,454,194 (59,497,415–74,654,738)

Abbreviation: DALYs, disability-adjusted life-years.
Note: Data from Feigin et al. Neuroepidemiology. 2015;45(3):161–176. doi:10.1159/000441085.

lifetime cost of ischemic stroke per person, which includes inpatient care, rehabilitation, and follow-up care, is estimated at $140,048 in the United States.[9]

The total annual direct costs were estimated at €26.6 billion in 2010 for the European Union (EU) plus Iceland, Norway, and Switzerland.[10] The economic burden caused by stroke has not been well explored in developing countries; according to estimates by the World Health Organization (WHO), India, for example, lost $8.7 billion in 2005 due to coronary heart disease (CHD), stroke, and diabetes. These numbers were thought at the time to increase up to $54 billion by 2015, and India's growth of gross domestic product (GDP) was estimated to fall by 1% because of the combined economic impact of CHD, stroke, and diabetes. For China, the estimated loss in national income between 2005 and 2015 as a result of premature deaths caused by CHD, stroke, and diabetes was $558 billion (WHO, Preventing Chronic Diseases: A vital investment, Geneva, Switzerland, 2005).

Inpatient hospital costs for acute stroke accounts for 70% of first-year poststroke costs.[11] Severe strokes (National Institutes of Health Stroke Scale [NIHSS] > 20) cost twice as much as mild strokes, despite similar diagnostic testing.[11] Costs and loss due to DALYs depend on the level of disability, and are generally higher for hemorrhagic versus ischemic stroke.[12,13] Evidence that specialized stroke rehabilitation reduces long-term disability and stroke-related costs exists for different countries and health care systems, including Switzerland,[14] the United Kingdom,[15,16] and Japan.[17] Cost effectiveness depends on the severity of disability: patients with moderate disability benefit more than those with severe or mild stroke severity.[17] Comorbidities such as ischemic heart disease and atrial fibrillation predict higher costs.[11] The American Heart Association projects the total cost of stroke, which encompasses both direct and indirect spending, to increase from $105.2 billion in 2012 to $240.7 billion by 2030.[18] It is likely that estimates of morbidity and cost burden, based on traditional measures such as physical disability and health care costs, underestimate the burden of cerebrovascular disease. It is increasingly appreciated, for example, that subclinical cerebrovascular disease—including so-called silent infarctions identified on brain imaging in ~28% of the population aged > 65 years[19]—is associated with memory loss, dementia, gait impairment, and other functional disability.[20]

Stroke Disparities

Stroke disparities are widespread and universal. Complex interwoven issues of inability to afford optimal medical infrastructure and personnel, unequal access to medical care (if available), low medical literacy, and problems with adherence and compliance all limit the effectiveness of primary and secondary prevention in stroke care.[21] Factors such as geography, age, sex, ethnicity, and socioeconomic status (SES) interact and modify the incidence and prevalence of stroke.

Age and Geography

The burden of stroke in people younger than 65 years has increased over the last few decades, with the incidence increasing worldwide by 25% among adults aged 20 to 64 years.[7] There is a concerning shift in the overall stroke burden toward younger age groups, particularly in low- and middle-income countries. The epidemic rise in cardiovascular risk factors in young adults in some regions such as Russia, China, and India has contributed to the increase in stroke burden among the younger population.[22–27] About 12% of strokes in India occur in the population younger than 40 years.[28] Stroke is an especially serious problem in Asia, which includes more than 60% of the world's population, and many of its countries are "developing" economies. Stroke mortality is higher in Asia than in Western Europe, the Americas, or Australasia, and is more similar to Eastern Europe.[29]

Paradoxically, increases in stroke risk and mortality in developing countries are associated with increasing SES, but decreases in stroke risk and mortality in developed countries are associated with increasing SES.[30] In rural villages in China, higher incomes brought prosperity but also brought higher stroke risk.[31] It is likely that when new monies enter a previously impoverished area, certain unhealthy behaviors are initially adopted.[32]

Ethnicity

Besides geographical disparities, there are also clear disparities between different race and ethnic groups. For example, there is a 200 to 300% excess mortality for blacks age 45 to 65 years compared with the Caucasian population in the United States.[33–35] In a similar fashion, Mexican Americans had a higher cumulative incidence of ischemic stroke at younger ages.[36] But also, in non-U.S. developed countries greater stroke risk and worse outcome is observed in ethnic minority populations compared with European origin populations.[37,38] About 50% of this excess is explained by traditional risk factors, mainly hypertension, as well as differences in SES, highlighting the importance of stroke prevention interventions aimed at minority groups.[39]

Socioeconomic Status

Stoke burden is clearly affected by SES, with greater odds of disability found in patients with lower education and income.[40] The South London Stroke registry found a 75% increased chance of poor outcome among the lowest SES group compared with the highest after controlling for clinical variables, including stroke severity.[41] The potent effect of SES on stroke outcomes suggests a tremendous need for improved resources for those recovering from stroke.[21]

Sex

Inequality in stroke mortality is also observed in women compared with men in many regions around the globe.[1] The WHO reported an excess of total stroke-related deaths among women compared with men between 1990 and 2006, of which 60% occurred in those aged over 75 years.[42] A study performed in 8 different European countries found that the risk of stroke increased by 9% per year in men and 10% per year in women.[43] This increased risk may be partly explained by the longer lifespan of women compared with men, and by the fact that hypertension and atrial fibrillation, key risk factors for stroke, are more frequent in women than in men.[44] But further differences in vascular biology, immunity, coagulation, hormonal profiles, lifestyle factors, and societal roles seem to contribute, especially due to risks related to pregnancy and the postpartum state.[44]

Conclusion

In conclusion, in the last decades, a substantial decrease of stroke incidence, mortality, and DALYs has been achieved in high-income countries, most likely due to improvement in primary and secondary prevention as well as acute stroke treatment and neurorehabilitation. However, stroke remains an important cause of disability and death worldwide. Globally, the burden of stroke has increased substantially over the past few decades due to expanding population numbers and aging as well as the increased prevalence of modifiable stroke risk factors, especially in low- and middle-income countries. The number of patients who will need care by clinicians with expertise in neurological conditions will continue to grow in the coming decades.[2]

Disclosures
None.

References

1 Mortality GBD; GBD 2015 Mortality and Causes of Death Collaborators. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet 2016;388(10053):1459–1544
2 Group GBDNDC; GBD 2015 Neurological Disorders Collaborator Group. Global, regional, and national burden of neurological disorders during 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet Neurol 2017;16(11):877–897
3 Feigin VL, Norrving B, Mensah GA. Global burden of stroke. Circ Res 2017;120(03):439–448
4 Kelly-Hayes M, Beiser A, Kase CS, Scaramucci A, D'Agostino RB, Wolf PA. The influence of gender and age on disability following ischemic stroke: the Framingham study. J Stroke Cerebrovasc Dis 2003;12(03):119–126
5 Feigin VL, Krishnamurthi RV, Parmar P, et al; GBD 2013 Writing Group; GBD 2013 Stroke Panel Experts Group. Update on the global burden of ischemic and hemorrhagic stroke in 1990–2013: the GBD 2013 study. Neuroepidemiology 2015;45(03):161–176
6 O'Donnell MJ, Xavier D, Liu L, et al; INTERSTROKE investigators. Risk factors for ischaemic and intracerebral haemorrhagic stroke in 22 countries (the INTERSTROKE study): a case-control study. Lancet 2010;376(9735):112–123
7 Krishnamurthi RV, Moran AE, Feigin VL, et al; GBD 2013 Stroke Panel Experts Group. Stroke prevalence, mortality and disability-adjusted life years in adults aged 20–64 years in 1990–2013: data from the global burden of disease 2013 study. Neuroepidemiology 2015;45(03):190–202
8 Struijs JN, van Genugten ML, Evers SM, Ament AJ, Baan CA, van den Bos GA. Future costs of stroke in the Netherlands: the impact of stroke services. Int J Technol Assess Health Care 2006;22(04):518–524
9 Johnson BH, Bonafede MM, Watson C. Short- and longer-term health-care resource utilization and costs associated with acute ischemic stroke. Clinicoecon Outcomes Res 2016;8:53–61
10 Gustavsson A, Svensson M, Jacobi F, et al; CDBE2010Study Group. Cost of disorders of the brain in Europe 2010. Eur Neuropsychopharmacol 2011;21(10):718–779
11 Go AS, Mozaffarian D, Roger VL, et al; American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics–2014 update: a report from the American Heart Association. Circulation 2014;129(03):e28–e292
12 Lekander I, Willers C, von Euler M, et al. Relationship between functional disability and costs one and two years post stroke. PLoS One 2017;12(04):e0174861
13 Barker-Collo S, Bennett DA, Krishnamurthi RV, et al; GBD 2013 Writing Group; GBD 2013 Stroke Panel Experts Group. Sex differences in stroke incidence, prevalence, mortality and disability-adjusted life years: results from the global burden of disease study 2013. Neuroepidemiology 2015;45(03):203–214
14 Mahler MP, Züger K, Kaspar K, et al. A cost analysis of the first year after stroke - early triage and inpatient rehabilitation may reduce long term costs. Swiss Med Wkly 2008;138(31-32):459–465

15 O'Connor RJ, Beden R, Pilling A, Chamberlain MA. What reductions in dependency costs result from treatment in an inpatient neurological rehabilitation unit for people with stroke? Clin Med (Lond) 2011;11(01):40–43
16 Turner-Stokes L, Williams H, Bill A, Bassett P, Sephton K. Cost-efficiency of specialist inpatient rehabilitation for working-aged adults with complex neurological disabilities: a multicentre cohort analysis of a national clinical data set. BMJ Open 2016;6 (02):e010238
17 Murata K, Hinotsu S, Sadamasa N, et al. Healthcare resource utilization and clinical outcomes associated with acute care and inpatient rehabilitation of stroke patients in Japan. Int J Qual Health Care 2017;29(01):26–31
18 Ovbiagele B, Goldstein LB, Higashida RT, et al; American Heart Association Advocacy Coordinating Committee and Stroke Council. Forecasting the future of stroke in the United States: a policy statement from the American Heart Association and American Stroke Association. Stroke 2013;44(08):2361–2375
19 Vermeer SE, Longstreth WT Jr, Koudstaal PJ. Silent brain infarcts: a systematic review. Lancet Neurol 2007;6(07):611–619
20 Boehme AK, Esenwa C, Elkind MS. Stroke risk factors, genetics, and prevention. Circ Res 2017;120(03):472–495
21 Morgenstern LB, Kissela BM. Stroke Disparities- large global problem that must be addressed. Stroke 2015. Doi: 10.1161/ STROKEAHA.115.009533
22 Danaei G, Finucane MM, Lin JK, et al; Global Burden of Metabolic Risk Factors of Chronic Diseases Collaborating Group (Blood Pressure). National, regional, and global trends in systolic blood pressure since 1980: systematic analysis of health examination surveys and epidemiological studies with 786 country-years and 5·4 million participants. Lancet 2011;377(9765):568–577
23 Norrving B, Kissela B. The global burden of stroke and need for a continuum of care. Neurology 2013;80(03, Suppl 2):S5–S12
24 de los Ríos F, Kleindorfer DO, Khoury J, et al. Trends in substance abuse preceding stroke among young adults: a population-based study. Stroke 2012;43(12):3179–3183
25 Zaridze D, Brennan P, Boreham J, et al. Alcohol and cause-specific mortality in Russia: a retrospective case-control study of 48,557 adult deaths. Lancet 2009;373(9682):2201–2214
26 Hu SS, Kong LZ, Gao RL, et al; Editorial Board. Outline of the report on cardiovascular disease in China, 2010. Biomed Environ Sci 2012;25(03):251–256
27 Jha P, Jacob B, Gajalakshmi V, et al; RGI-CGHR Investigators. A nationally representative case-control study of smoking and death in India. N Engl J Med 2008;358(11):1137–1147
28 Pandian JD, Sudhan P. Stroke epidemiology and stroke care services in India. J Stroke 2013;15(03):128–134
29 Venketasubramanian N, Yoon BW, Pandian J, Navarro JC. Stroke epidemiology in south, east, and south-east Asia: a review. J Stroke 2017;19(03):286–294
30 Wu SH, Woo J, Zhang XH. Worldwide socioeconomic status and stroke mortality: an ecological study. Int J Equity Health 2013; 12:42
31 Tang X, Laskowitz DT, He L, et al. Neighborhood socioeconomic status and the prevalence of stroke and coronary heart disease in rural China: a population-based study. Int J Stroke 2015;10(03): 388–395
32 Morgenstern LB, Kissela BM. Stroke disparities: large global problem that must be addressed. Stroke 2015;46(12):3560–3563
33 Murray CJ, Atkinson C, Bhalla K, et al; U.S. Burden of Disease Collaborators. The state of US health, 1990-2010: burden of diseases, injuries, and risk factors. JAMA 2013;310(06): 591–608
34 Mozaffarian D, Benjamin EJ, Go AS, et al; Writing Group Members; American Heart Association Statistics Committee; Stroke Statistics Subcommittee. Heart disease and stroke statistics-2016 update: a report from the American Heart Association. Circulation 2016;133(04):e38–e360
35 Kissela BM, Khoury JC, Alwell K, et al. Age at stroke: temporal trends in stroke incidence in a large, biracial population. Neurology 2012;79(17):1781–1787
36 Morgenstern LB, Smith MA, Lisabeth LD, et al. Excess stroke in Mexican Americans compared with non-Hispanic Whites: the Brain Attack Surveillance in Corpus Christi Project. Am J Epidemiol 2004;160(04):376–383
37 McNaughton H, Feigin V, Kerse N, et al; Auckland Regional Community Stroke Study Group. Ethnicity and functional outcome after stroke. Stroke 2011;42(04):960–964
38 Bhopal RS, Bansal N, Fischbacher CM, Brown H, Capewell S; Scottish Health and Ethnic Linkage Study. Ethnic variations in the incidence and mortality of stroke in the Scottish Health and Ethnicity Linkage Study of 4.65 million people. Eur J Prev Cardiol 2012;19(06):1503–1508
39 Howard G, Prineas R, Moy C, et al. Racial and geographic differences in awareness, treatment, and control of hypertension: the REasons for Geographic And Racial Differences in Stroke study. Stroke 2006;37(05):1171–1178
40 Bettger JP, Zhao X, Bushnell C, et al. The association between socioeconomic status and disability after stroke: findings from the Adherence eValuation After Ischemic stroke Longitudinal (AVAIL) registry. BMC Public Health 2014;14:281
41 Chen R, Crichton S, McKevitt C, Rudd AG, Sheldenkar A, Wolfe CD. Association between socioeconomic deprivation and functional impairment after stroke: the South London Stroke Register. Stroke 2015;46(03):800–805
42 Redon J, Olsen MH, Cooper RS, et al. Stroke mortality and trends from 1990 to 2006 in 39 countries from Europe and Central Asia: implications for control of high blood pressure. Eur Heart J 2011; 32(11):1424–1431
43 Asplund K, Karvanen J, Giampaoli S, et al; MORGAM Project. Relative risks for stroke by age, sex, and population based on follow-up of 18 European populations in the MORGAM Project. Stroke 2009;40(07):2319–2326
44 Cordonnier C, Sprigg N, Sandset EC, et al; Women Initiative for Stroke in Europe (WISE) group. Stroke in women - from evidence to inequalities. Nat Rev Neurol 2017;13(09):521–532