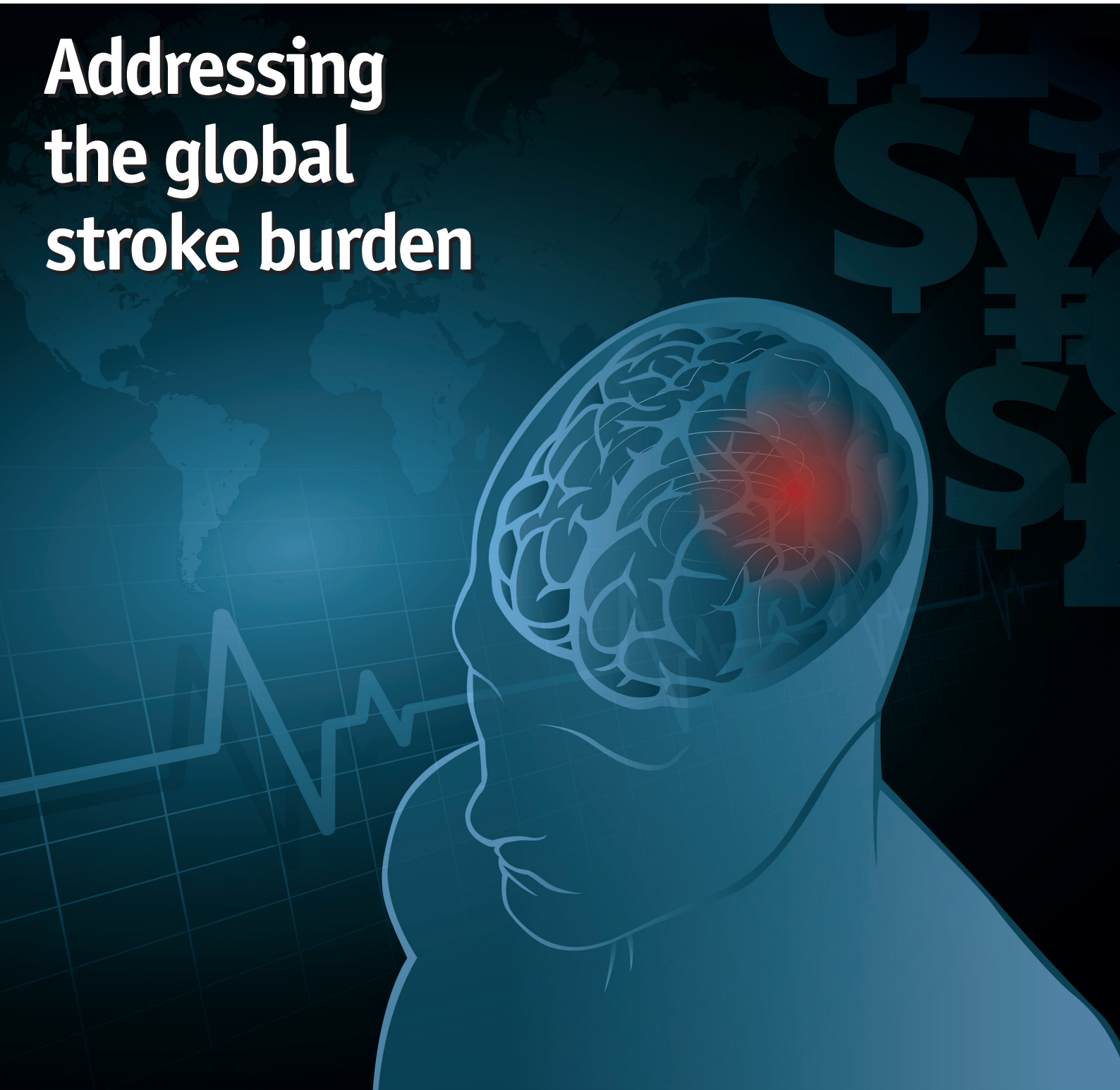


Addressing the global stroke burden



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ABOUT THIS REPORT

Addressing the global stroke burden is an Economist Intelligence Unit (EIU) report, sponsored by AstraZeneca. It assesses the burden of stroke across the globe, examines current policy approaches to combatting the disease, and explores further possible measures to help tackle stroke.

In February-March 2016 The EIU conducted nine interviews with experts on stroke, including academics, medical practitioners and policy advisers. The insights from these interviews appear throughout the report. The EIU would like to thank the following individuals (listed alphabetically) for sharing their insight and experience:

- Professor Valery Feigin, director, National Institute for Stroke and Applied Neurosciences, AUT University, New Zealand
- Professor Werner Hacke, senior professor of neurology, University of Heidelberg Medical School, Germany
- Dr Sheila Cristina Ouriques Martins, founder, Brazilian Stroke Network, Brazil
- Dr Hirofumi Nakayama, executive director, Japan Stroke Association, Japan
- Professor Bo Norrving, professor of neurology, Lund University, Sweden
- Dr Oyere K Onuma, medical officer, Cardiovascular Diseases, Department for Management of Non-communicable Diseases, Disability, Violence and Injury Prevention, World Health Organisation, Switzerland
- Professor Tony Rudd, national clinical director for stroke, NHS England, UK
- Professor Ralph L Sacco, Olemberg chair of neurology, Miller School of Medicine, University of Miami, US
- Dr Lijing L Yan, head, non-communicable disease research, Global Health Research Centre, Duke Kunshan University, China; and Duke Global Health Institute, Duke University, US

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April 2016

EXECUTIVE SUMMARY

The socioeconomic burden of stroke looks set to become increasingly heavy on high-income as well as on low- and middle-income countries in the decades ahead. The prevalence of stroke is likely to continue to rise, leading to further costs, including direct costs (such as healthcare) and indirect costs (such as lost productivity due to absenteeism from the workplace or presenteeism).

This report, based on in-depth interviews with nine experts on stroke from around the globe, assesses current developments and the economic burden of stroke across the regions of the world. It also presents examples of effective policy responses to stroke, including measures aimed at prevention, treatment and rehabilitation. Finally, this report assesses what policymakers and medical practitioners need to do if the burden of stroke is to be eased. The main findings of the research are presented below.

Low- and middle-income countries are particularly at risk from the rising cost burden of stroke in the coming decades. The prevalence of stroke in high-income countries is rising as populations age. Meanwhile, in low- and middle-income countries the Westernisation of diets and lifestyles, coupled with rising levels of obesity and diabetes, represents a significant risk factor for stroke.

Policymakers' efforts to tackle stroke appear to have been particularly effective in the areas of prevention and the organisation of stroke care. Experts describe improvements in primary and secondary stroke prevention as paramount in tackling the disease. Not least, medical practitioners are better able to control blood pressure, high cholesterol levels and diabetes today than in the past, while lifestyles are improving in many high-income countries.

If UN and World Health Organisation (WHO) targets aimed at reducing non-communicable diseases including stroke are to be met, policymakers must take urgent action. There is scope to improve education around the risk factors for stroke and the recognition of stroke. Improved medical data and better management of existing medical conditions may help. New technology has a role to play too, as does improved access to healthcare and medication.

INTRODUCTION

As the second leading cause of death globally in 2012, stroke represents a significant disease burden across the world. It is the second most common cause of death in low- and middle-income countries and the third most common in higher-income countries. Stroke is also a major cause of adult disability.

The prognosis for the decades ahead indicates that the prevalence of stroke will probably continue to grow in low- and middle-income countries as the fall in the age-adjusted stroke mortality in these countries fails to counteract the ongoing changes in their populations and their lifestyles. Of note is the growing prevalence of obesity and diabetes, which are significant stroke risk factors; these conditions are spreading among young people, and in low- and middle-income countries in particular. It is these countries that are likely to account for the bulk of increased future predictions in terms of numbers of strokes occurring in the world. In high-income countries, prevalence is likely to continue rising, despite falling incidence rates as populations age further.

The socioeconomic costs of stroke are heavy. In the EU, the financial burden of stroke is about €62bn (US\$70bn) per year and accounts for around for 2-3% of the entire healthcare expenditure in the region.¹ In the US, the total cost of stroke in 2010 was estimated at US\$73.7bn by the US National Stroke Association; this includes the direct cost of medications to treat stroke as well as healthcare services, for example in hospitals or nursing homes, by physicians, home healthcare etc (making up more than 60% of the total costs) and indirect costs such as lost productivity (making up almost 40% of the total costs).²

As the burden of the disease grows in low- and middle-income countries, these countries will also face significant increases in socioeconomic costs associated with stroke. In China, for example, total hospitalisation expenditure for all cardiovascular disease, including stroke, already reached over Rmb40bn (US\$6.2bn at current exchange rates) in 2011, or an estimated 1.6% of national health expenditure.³

The research in this report is based on in-depth interviews with experts on stroke, including academics, policy advisers and practitioners, and on published research. The purpose of this paper is to examine current developments in addressing stroke across the globe and to assess the socioeconomic cost burden of the disease. Furthermore, this research seeks to assess effective policy responses and to identify areas of policy that must be addressed if the burden of stroke is to be eased.

¹ StopAfib.org, *How Can We Avoid a Stroke Crisis in Europe?*, October 2012. Available at: <http://www.stopafib.org/downloads/News436.pdf>

² National Stroke Association, "Explaining Stroke 101". Available at: https://www.stroke.org/sites/default/files/resources/Presentation_Explaining%20Stroke%20101.ppt.

³ Wang, S, Petzold, M *et al*, "Direct Medical Costs of Hospitalizations for Cardiovascular Diseases in Shanghai, China", *Medicine* (Baltimore), May 2015; 94(20).

CHAPTER 1: THE GROWING BURDEN OF STROKE

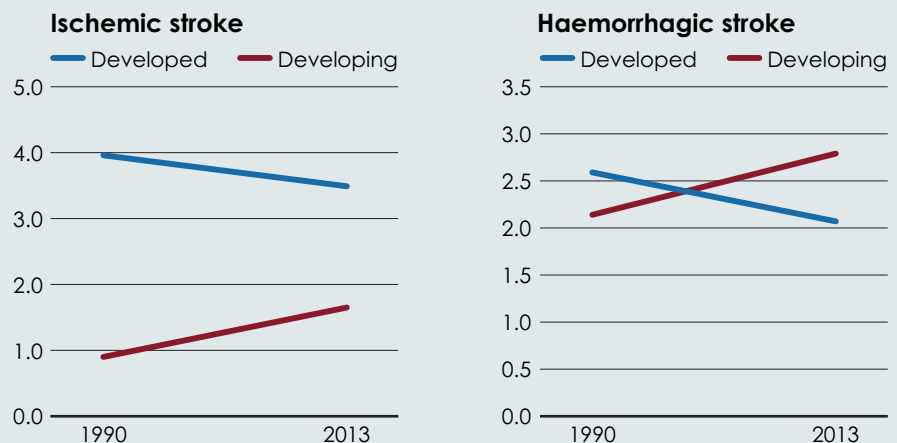
Stroke remains a significant burden across the globe. According to the World Heart Federation, every year 15m people worldwide have a stroke; of these, almost 6m die and another 5m are left with permanent disabilities. After dementia, stroke is also the second leading cause of disability, which can include loss of vision and/or speech, paralysis and confusion.⁴

According to World Health Organisation (WHO) data for 2012, stroke was the second leading cause of death globally. It is the second most common cause of death in low- and middle-income (or developing) countries and the third most common in higher-income (or developed) countries. Besides causing death, stroke is also a major cause of adult disability. It was the third leading cause of disability-adjusted life years (DALYs) lost worldwide in 2012, according to WHO data. In all, 113m DALYs were lost as a result of stroke in 2013.⁵

Against this background, stroke is becoming more significant relative to other illnesses. The contribution of DALYs due to stroke as a share of all conditions rose from 3.5% to 4.6% between 1990 and 2013 (see Figure 1), while the proportion of deaths due to stroke rose from 9.7% to 11.8% in the same timeframe (see Figure 2). Here, the increase in the contribution of DALYs and deaths was largely attributable to low- and middle-income countries; there was no significant rise in the proportion of DALYs or deaths due to stroke in high-income countries.⁶

Figure 1

Trends in contribution to DALYs due to ischemic stroke (IS) and haemorrhagic stroke (HS) as a percentage of all conditions



Note: IS occurs when an artery to the brain is blocked, while HS is caused by bleeding of a blood vessel supplying the brain.

Source: Feigin VL, Krishnamurthi RV et al, "Update on the Global Burden of Ischemic and Hemorrhagic Stroke in 1990–2013: The GBD 2013 Study", *Neuroepidemiology*, 2015;45(3):161-76.

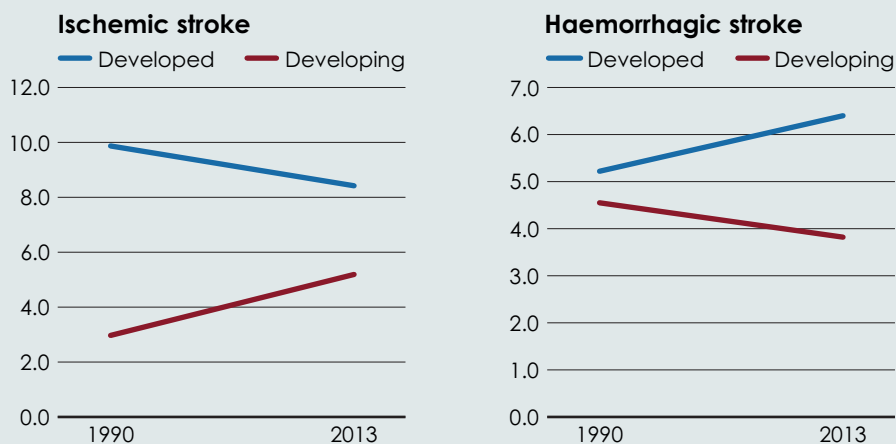
⁴ World Heart Federation, *Stroke*. Available at: <http://www.world-heart-federation.org/cardiovascular-health/stroke/>

⁵ Feigin VL, Krishnamurthi RV et al, "Update on the Global Burden of Ischemic and Hemorrhagic Stroke in 1990–2013: The GBD 2013 Study", *Neuroepidemiology*, 2015; 45(3):161-76.

⁶ Krishnamurthi, RV, Moran, AE et al, "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; 45:190–202.

Figure 2

Trends in contribution to death due to stroke as a percentage of all conditions



Note: IS occurs when an artery to the brain is blocked, while HS is caused by bleeding of a blood vessel supplying the brain.

Source: Feigin VL, Krishnamurthi RV et al. "Update on the Global Burden of Ischemic and Hemorrhagic Stroke in 1990–2013: The GBD 2013 Study", *Neuroepidemiology*, 2015;45(3):161-76.

Furthermore, there is a strong divergence between high-income countries and low- and middle-income countries. In high-income countries, age-adjusted incidence of stroke has seen a clear reduction since 1990 (see Figure 3). "What's driving the reduction in incidence [in high-income countries] is almost certainly better lifestyle, reduction in the number of people with high blood pressure and smoking and excess alcohol," says Professor Tony Rudd, national clinical director for stroke at NHS England, which is part of the UK's Department of Health. At the same time, however, prevalence remains on the rise in many high-income countries: stroke is predominant among the older age groups that are growing rapidly in high-income countries (see Figure 4).

Meanwhile, the majority of the burden of stroke is to be found in low- and middle-income countries: 2013 data indicate that 75.2% of deaths caused by stroke and 81% of DALYs lost as a result of stroke across the globe occur in low- and middle-income countries.⁷ Many infectious diseases in low- and middle-income countries have been conquered, and populations are becoming more Westernised in their diet and lifestyle. "About 40-50 years ago people in rural China were suffering from undernutrition," points out Dr Lijing Yan, head of non-communicable disease research at the Global Health Research Centre at Duke Kunshan University in China and the Duke Global Health Institute at Duke University in the US. "Now it's more malnutrition, in that they're getting their calorific intake mostly from fat and sugar and salt." In many low- and middle-income countries, policymakers have not taken measures to address these issues.

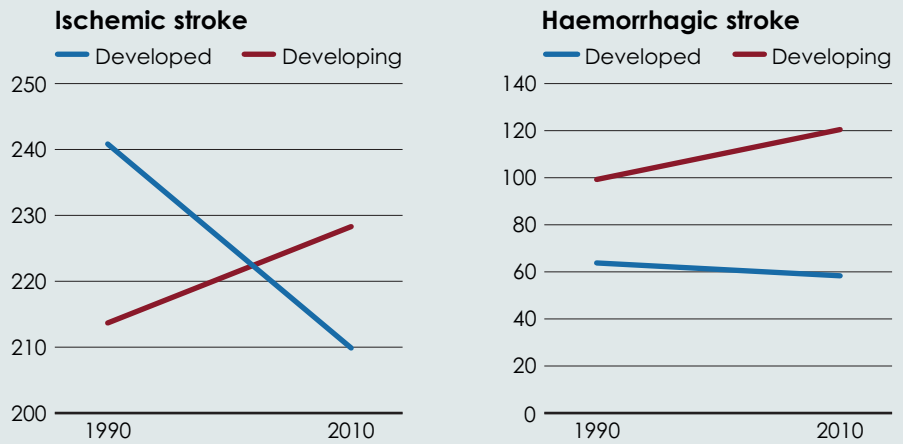
In the decades ahead, experts forecast, the fall in the age-standardised stroke mortality rate in low- and middle-income countries is unlikely to be enough to counteract the

⁷ Feigin et al, "Update on the Global Burden of Ischemic and Hemorrhagic Stroke".

ADDRESSING THE GLOBAL STROKE BURDEN

Figure 3

Trends in stroke incidence rates between 1990 and 2010
(age standardised; rates per 100,000)



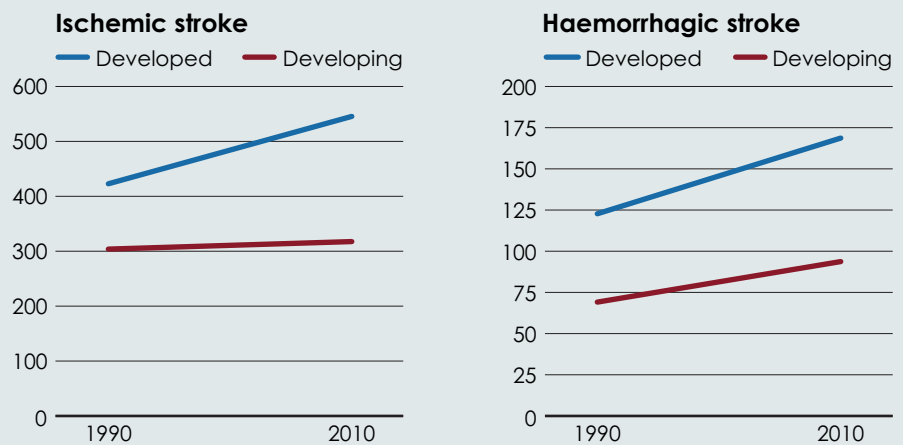
Note: IS occurs when an artery to the brain is blocked, while HS is caused by bleeding of a blood vessel supplying the brain.

Source: Krishnamurthi, RV, Moran, AE *et al*, "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;45:190-202.

ongoing changes in the population, meaning that prevalence of stroke will probably continue to grow in those countries. "The biggest driver of the increased future predictions in terms of numbers of strokes occurring in the world is the increased numbers

Figure 4

Trends in stroke prevalence rates between 1990 and 2010
(age standardised; rates per 100,000)



Note: IS occurs when an artery to the brain is blocked, while HS is caused by bleeding of a blood vessel supplying the brain.

Source: Krishnamurthi, RV, Moran, AE *et al*, "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;45:190-202.

of strokes occurring in developing countries," comments Professor Ralph Sacco, chairman of neurology at the Miller School of Medicine at the University of Miami in the US.

This effect is likely to be compounded by the growing prevalence of obesity and diabetes, especially in young people. "Although not immediately resulting in stroke, these risk factors are like a time bomb," says Professor Valery Feigin, director of the National Institute for Stroke and Applied Neurosciences at AUT University in New Zealand. "After 20-30 years of exposure to increased body weight or diabetes, we can expect an explosion of new strokes," he says. "If these basic beginnings are not stopped, you will have a huge increase in the number of strokes as a result."

QUANTIFYING THE COST OF STROKE

To date, there has been little research into the cost of stroke relative to research into the cost of other acute health conditions. However, a small number of landmark research projects in the past two decades have made significant advances in estimating the cost burden of stroke.

Scholarly research published in the US in 1996 found that the reported lifetime cost of one ischemic stroke event, which occurs when an artery to the brain is blocked, averaged US\$91,000 in 1990, while the lifetime cost of a subarachnoid haemorrhage, caused by bleeding on the surface of the brain, topped US\$228,000.⁸

Given that around 800,000 people each year in the US have a primary or recurrent stroke, the total cost of stroke in 2010 was estimated at US\$73.7bn by the US National Stroke Association.⁹

Of this amount, over 60% were direct costs of healthcare such as hospital expenses and costs associated with nursing homes, healthcare professionals,

medication and care in the home. Nearly 40% of this was accounted for by indirect costs, such as lost productivity and mortality.

Looking ahead to 2050, the total cost of stroke in the US between 2005 and 2050 will reach around US\$2.2trn if no measures are taken to enhance preventive care or therapy, according to 2006 research.¹⁰

Meanwhile, in the UK, research published in 2009 attempted to estimate the annual cost of stroke to the UK economy.¹¹ The research included diagnosis, inpatient care and outpatient care in its estimate of direct costs; its estimate of indirect costs included income loss and social benefit payments to stroke survivors.

In all, the research put the total cost of the treatment of stroke and the productivity loss arising from stroke at £8.9bn (US\$12.9bn) annually, with direct care accounting for around half of this amount, informal care costs for 27% and indirect costs for 24%.

⁸ Taylor TN, Davis PH *et al*, *Lifetime cost of stroke in the United States*. *Stroke* 1996;27(9):1459-1466.

⁹ National Stroke Association, *Explaining Stroke* 101

¹⁰ Brown DL, Boden-Albala B *et al*, "Projected costs of ischemic stroke in the United States", *Neurology*, 2006 Oct 24;67(8):1390-5.

¹¹ Saka, Ö, McGuire, A and Wolfe, C, "Cost of stroke in the United Kingdom", *Age Ageing* (2009) 38 (1): 27-32.

The consequences of stroke

The costs of stroke include direct costs such as those associated with acute treatment, but in many cases also rehabilitation and lifetime care following a stroke (see Box: Quantifying the cost of stroke). Around three-quarters of patients remain disabled following a stroke, and around half need help from others in their everyday activities, according to Professor Feigin. Stroke is a condition which, in many cases, does not kill but leaves survivors with long-term disabilities. "Stroke is one of the most expensive diseases in the world, and the cost of stroke in economic terms is increasing probably faster than from any other condition," Professor Feigin adds.

The economic cost of stroke is set to place an increasingly heavy burden on low- and middle-income countries as the number of stroke events continues to rise and mortality rates continue to fall. "When we talk about stroke mortality in North America and western Europe, we are talking about 10-15%, but when we talk about stroke mortality in China, Russia or India, we are talking about 30-50%," says Professor Werner Hacke, senior professor of neurology at the University of Heidelberg in Germany. For now, though, these higher mortality rates keep the economic burden of stroke in check, he points out, with relatively fewer surviving patients requiring rehabilitation and lifetime care.

Besides direct costs such as the expense of treatment, stroke also incurs heavy indirect costs, not least the effect of lost economic productivity. Around 50% of all strokes occur among people of working age, according to Professor Feigin. "Stroke affects the productivity of the patients themselves as well as of the family caregivers," says Dr Yan. "Typically, disabled stroke patients need to be taken care of by their families, and that will cause absenteeism or presenteeism and reduce productivity."

The wider costs of stroke at a societal level are difficult to quantify, yet the consequences are also grave. The psychological, emotional, physical and also financial effects on stroke survivors and their family members, who are often caregivers, are enormous. "If you survive a heart attack, you're usually not disabled," notes Professor Feigin. "But three-quarters of stroke survivors remain disabled, about 50% of them require some help from others for their everyday activities, and one-quarter are bedridden."

The socioeconomic cost of stroke is especially evident in some low- and middle-income countries. "Stroke is among the leading causes of family poverty in rural China," says Dr Yan. "Families sometimes escape poverty through their own efforts, but then somebody can fall ill in their family with a highly disabling condition like stroke and return the family to poverty. In the community, there are certain areas with a higher burden of stroke than in others, and you can see the impact of that on their social and economic well-being." Addressing the burden of stroke clearly has the potential to lead to significant socioeconomic benefits.

CHAPTER 2: POLICIES AND INITIATIVES TO COMBAT STROKE

Until quite recently, stroke was largely absent from the agenda of the international community. In 2011, though, the UN adopted a resolution on non-communicable diseases (NCDs), in which stroke was highlighted as an urgent health issue. In 2013 the World Health Assembly endorsed the WHO Global Action Plan for the Prevention and Control of NCDs 2013-2020 to tackle NCDs. And in 2015 the UN announced its Sustainable Development Goals, including a target to reduce by one-third premature deaths from NCDs by 2030.

Initiatives such as these mark progress in combatting the burden of stroke. Yet they also draw criticism. Consider, for example, the WHO Global Action Plan for the Prevention and Control of NCDs, which targets a 25% reduction in premature mortality from NCDs by 2025. “A reduction in stroke mortality will result in an increased number of disabled people with stroke,” argues Professor Feigin. “For stroke, the most appropriate health target would be a reduction in the number of people affected by stroke in the first place, and a reduction in disabilities from stroke.”

According to experts such as Professor Feigin, at least 80% of strokes could be avoided if people were aware of their risk factors and knew how to reduce them, and global policy frameworks aimed at tackling NCDs are likely to prove effective in preventing stroke. “At the WHO we have the framework convention for tobacco control, policies that address decreased salt use and policies to encourage healthy lifestyle choices, such as increased physical activity, to reduce poor nutrition and to educate the population,” says Dr Oyere Onuma, a medical officer in cardiovascular diseases at the WHO. “That level of response is critical in addressing the overall stroke burden.”

Besides global initiatives such as these, the World Stroke Organisation also supports a number of “best buys” in combatting the disease set out by the WHO. “It’s very clear that for the prevention of stroke, the most cost-effective thing is primary prevention by governmental actions on high-risk factors,” says Bo Norrving, professor of neurology at Lund University in Sweden. These actions include raising taxes on tobacco, alcohol and unhealthy food, putting in place measures to reduce salt and sugar, and promoting physical activity. “If you take measures against tobacco, it has an immediate effect on health,” Professor Norrving adds.

Experts interviewed for this research point out that until recently policymakers have largely focused on acute stroke care and secondary stroke prevention—but that attention is now shifting to primary stroke prevention. “I think we’ve seen a lot more improvement on the prevention side, because we do have more medications for blood pressure, cholesterol and diabetes management, and lifestyle modification is improving,” according to Professor Sacco.

Still, secondary prevention remains an important element in the fight against stroke. Almost one-third of all strokes (25-30%) occur in individuals who have had a previous stroke event.¹² A focus on traditional risk factors is crucial. For example, atrial fibrillation (AF) is a condition which increases the risk of stroke fivefold and is responsible for up to 30% of all strokes caused by blood clots.¹³ Other risk factors include tobacco use, alcohol consumption, obesity and high blood pressure. "With antithrombotics, blood pressure-lowering medication, statins, carotid interventions and lifestyle and anti-smoking advice recurring stroke could be reduced by two-thirds or even more," says Professor Norrving. "This is a very effective package in high-risk individuals."

Policy towards therapy

While experts describe improvements in primary stroke prevention as paramount in tackling the disease, some policy measures aimed at improving therapy have proven effective. In the US one of the most significant policy changes has been the organisation of stroke care. "We certify what are called Primary Stroke Centres that can deliver a tissue plasminogen activator (tPA), Comprehensive Stroke Centres that do more of the interventional procedures, and Acute Stroke-Ready Hospitals that can accept a patient with stroke but then get them triaged appropriately to the higher-level stroke centre after they stabilise them," Professor Sacco explains.

Meanwhile in London, policymakers made the decision in 2010 to reduce the number of acute units treating stroke patients from 32 to just eight. "Bigger units work more effectively than smaller units, and it's a more cost-effective way of delivering care as well," explains Professor Rudd. Given the effectiveness of acute stroke care in treating the disease, this measure has shown positive results, he adds. "It has been very successful in reducing mortality, reducing disability and improving the processes of care."

Acute stroke centres such as these also provide a foundation for rolling out new treatments. One example is the use of catheters to remove blood clots. Professor Sacco explains that in Comprehensive Stroke Centres medical practitioners can thread catheters up arteries in the body to the brain and remove the clot from a blocked artery. Currently, these interventional procedures are carried out only in selected Comprehensive Stroke Centres within six hours of the stroke. Researchers are trying to extend that time window to roll out the treatment to larger segments of the population.

Meanwhile, effective policy measures to promote improvements in rehabilitation appear more difficult to capture. Whereas it may be straightforward to gauge the types of medication or acute therapies a stroke survivor may need, rehabilitation is much broader, with many alternatives such as inpatient, outpatient or day clinics, and can take the form of home rehabilitation or rehabilitation in specialised units or in nursing homes where there is a rehabilitation component. "It is much more difficult to say what is enough for this patient," says Professor Norrving. "It is really difficult to measure rehabilitation and to capture if it's enough or not."

¹² Hankey, GJ, "Secondary stroke prevention", *Lancet Neurology*, February 2014; 13(2):178-94.

¹³ StopAfib.org, *How Can We Avoid a Stroke Crisis in Europe?*

This is not to say that there is no scope for new measures in rehabilitation. However, some new policy approaches towards rehabilitation are emerging. One example of a new method is botulinum toxin treatment, which relaxes rigid muscles and enables more effective rehabilitation, points out Dr Hirofumi Nakayama, a medical practitioner in Japan and the executive director of the Japan Stroke Association. He also highlights transcranial magnetic stimulation of the brain as a new treatment. Further approaches to rehabilitation undergoing clinical trials include weightlifting machines in which the patient is suspended to facilitate walking. "Such an approach has been proven effective," says Dr Nakayama. "There are many new trials of rehabilitation methods."

BRAZIL'S NATIONAL STROKE PROJECT

Stroke management in Brazil has come a long way since the country's first stroke unit opened its doors in 1995. By 2008 the Brazilian Stroke Society had helped to establish 35 stroke centres in the country, showing policymakers that it is possible to organise a stroke system of care in Brazil.

In June 2008 the Brazilian Ministry of Health initiated the National Stroke Project to improve the care of stroke patients by implementing stroke services throughout the country. Today there are around 130 stroke centres working in different regions of Brazil.

As part of the National Stroke Project the Hospital de Pronto Socorro in Canoas, a city near Porto Alegre, was also the first in the country to introduce the use of stroke telemedicine.

The project has had impressive results: where previously stroke had been the leading cause of death, the mortality rate from stroke in Brazil fell from 18% to 11% in 2011, according to Dr Sheila Cristina Ouriques Martins, founder of the Brazilian Stroke Network, who has

ambitions to continue to increase the number of hospital stroke centres across the country.

What comes next for stroke care in the country? Dr Martins explains that she is hoping to see the use of thrombectomy—a procedure to treat and remove a blood clot—in public hospitals. "We have the trials showing that thrombectomy is level 1a of evidence for treatment of severe stroke, but we don't yet have it in public hospitals," she says. She plans to start trials in 12 public hospitals this year.

Another priority is to establish a national stroke registry. "We have data from the Ministry of Health about mortality, about the number of stroke patients assisted, but we need more," she says. "We need to know at least the functional outcome of patients and the indicators of process inside the hospitals to know if everything is going well."

CHAPTER 3: FURTHER MEASURES TO TACKLE STROKE

In efforts to combat stroke, what more can policymakers do? First, there may be scope to improve education around the risk factors for stroke—not only among those most at risk from stroke but among other segments of the population too. “It’s very cheap if you do it in the primary or secondary school education, and it is very important, because young people start their habits in their teenage years,” says Dr Nakayama. “We have asked the Ministry of Education about introducing education for health problems, but they just say, ‘We don’t have enough time’.”

More education is also needed in recognising stroke. Of those who have the approximately 800,000 strokes in the US each year, just 5-10% receive acute care, even though 85% live within an hour of a stroke centre for rapid acute stroke treatment. “The biggest issue with acute stroke treatment is that not enough of the public recognise stroke symptoms fast enough to get urgent attention,” says Professor Sacco of the University of Miami. “Like every educational campaign, it needs constant reinforcement.”

A further measure to help prevent stroke is improved medical data. Dr Onuma of the WHO says that policymakers do not have reliable data on stroke mortality and stroke incidence, specifically in low- and middle-income countries. “The absence of reliable data complicates our understanding of the trends and the specific policy and health system actions that can be taken to address those trends,” she says. “An improvement in vital registration systems and the establishment of stroke registries in a few key sites will be very important in addressing the challenge of stroke.”

Improved management of existing medical conditions could also help to prevent stroke. This includes identifying and treating patients with atrial fibrillation, for example. Dr Yan of Duke Kunshan University points out that stroke patients require long-term, regular management for their blood pressure, among other things. Yet most patients in China are not getting this kind of routine management. For one thing, the number of stroke patients is simply too large for the specialists available, Dr Yan says; for another, the awareness of this kind of management is not there.

Better management of existing conditions may be particularly effective in preventing secondary stroke. In secondary prevention, the bulk of healthcare management is identical to that for primary stroke prevention. Yet “in preventing a second stroke, you will most likely know the etiology of the first stroke”, comments Professor Hacke of Heidelberg University. “So you know what the mechanism was that led to this stroke, and this peculiar mechanism may require very specific preventative tools that would not work for other etiologies.” This way, according to Professor Hacke, “the risk of subsequent strokes may be reduced massively”.

The development of new technology to monitor risk factors is important, too. Dr Nakayama of the Japan Stroke Association comments that it is possible to monitor risk factors like blood pressure more closely using technology such as a blood-pressure measurement device connected to a communications device that transmits the data to a health centre. Furthermore, he says, “if you develop a blood-sugar sensor which transmits the blood-sugar level automatically to the centre or doctors, and an electrocardiogram which will be monitored automatically, then we can find the risk factors and monitor them.”

Improved access to medication

Medication presents similar issues. The proportion of stroke patients in low- and middle-income countries who continue treatment with drugs to prevent a secondary stroke is small, either because the drugs are not locally available or because they are too costly. “Key standard medications that one would need are still not available and affordable in most contexts for people,” says Dr Onuma. Ensuring the availability of basic medication in low- and middle-income countries is critical to combatting stroke.

THE STROKE RISKOMETER APP

The neuroscience team at the National Institute for Stroke and Applied Neurosciences at AUT University in New Zealand has developed a smartphone app to enable users to monitor their risk of stroke while contributing data and epidemiological insights to a worldwide research effort.

The Stroke Riskometer app, which is endorsed by the World Stroke Organisation, the World Federation of Neurology, the European Stroke Organisation and the World Heart Federation, enables users to assess their individual stroke risk on a smartphone or tablet.

The assessment process has a standard questionnaire to assess patient risk. Users

need only input their modifiable and non-modifiable risk factors. Modifiable risk factors include questions about lifestyle, levels of stress and a health history; non-modifiable risk factors include age, sex, race and ethnicity and family history.

Information on non-modifiable risk factors is cross-referenced with modifiable factors. The Stroke Riskometer is based on evidence-based algorithms. Results are presented as a calculated percentage of stroke risk over a five- and ten-year period, assuming the user's habits do not change. The app includes signs and symptoms that may occur at the onset of stroke and provides tailored recommendations on how users can best control their risk factors.

China is a clear example of a country where improved access to healthcare, including primary healthcare and medication following a stroke, can be improved to prevent a secondary stroke. There, secondary healthcare is free for patients, while primary healthcare is not. Hence, after leaving hospital following a stroke many patients discontinue treatment and check-ups, such as monitoring their blood pressure, which may be critical in preventing a recurrence of stroke. In cases such as this, improved access to primary healthcare facilities can make a significant difference to the incidence of a secondary stroke.

In order to tackle stroke, ongoing improvements in healthcare infrastructure may be needed, even in the most developed countries. New technologies such as telemedicine enable the delivery of acute care to rural areas or the delivery of rehabilitation. “[Telemedicine] is quite widely used in some parts of the UK where we don’t have access to, for example, enough consultants to provide a 24/7 rota in every hospital,” says Professor Rudd of NHS England. Similar technologies have been rolled out in some Scandinavian countries and in the US, too.

Furthermore, progress in rehabilitation lags behind advancements made in stroke prevention and acute stroke treatment. In New Zealand, for example, only one in five people who are discharged from the hospital receive rehabilitation in the community—and then only for three months or so, according to Professor Feigin of AUT University. “Stroke recovery is a continuing process, but 80% of stroke survivors are on their own after they are discharged from hospital,” he says. “If this trend is not reversed, or at least stopped, it could have a devastating effect on the economy of many countries.”

Dr Onuma points out that standard post-stroke rehabilitation based at a facility is typically out of reach for most people in low- and middle-income countries, and that innovations such as at-home rehabilitation fulfil this need while making the services more convenient and more affordable for patients and their families. “There are trials of this on the way in India and other places, looking at how this can fit into the overall stroke care system,” she says.

Finally, many health systems, in high-income and low- and middle-income countries alike, are in need of clearly defined care pathways from stroke prevention to rehabilitation. “[In China] there is no clear, coherent pathway that people follow [to] stop that endless cycle of increasing disability and recurrent strokes,” Professor Rudd explains. “So that’s one example of failing to recognise that if you don’t work coherently as a team, with health and social care working together, with a health service that addresses the needs of the patients in terms of their financial need and their medical needs, you can end up with an incredibly wasteful system.”

CONCLUSION

Stroke is placing an increasingly heavy socioeconomic burden on high-income and low- and middle-income countries alike. Experts forecast that the prevalence of stroke will continue to grow, leading to further costs, including direct costs such as healthcare, indirect costs such as lost productivity, and other social costs. These costs are likely to be felt all the more strongly in low- and middle-income countries in the coming decades.

Examples of good practice in stroke prevention, therapy and rehabilitation provide useful insights for those countries wishing to improve their stroke management programmes. These practices include programmes to reduce risk factors such as high blood pressure, smoking and poor diet; organisation of stroke care, for example in the US, has also delivered improvements in outcomes.

Still, much remains to be done if the UN's Sustainable Development Goal of reducing by one-third premature deaths from non-communicable diseases by 2030 is to be met. In order to make progress towards this and other stroke-reduction goals, policymakers in high-income and low- and medium-income countries alike must give urgent consideration to policies and initiatives, including the following:

- **Improve education** around the risk factors for stroke, such as tobacco use, alcohol consumption, salt and sugar intake and lack of physical exercise. Better education is also needed in recognising stroke to increase the proportion of stroke survivors who receive the urgent attention they need.
- **Enhanced medical data** may also help combat stroke, particularly in low- and middle-income countries where reliable data are absent. An improvement in vital registration systems and the establishment of stroke registries in a few key sites will be very important in addressing the challenge of stroke.
- **Better management of existing medical conditions** could also help to prevent both primary and secondary stroke, including regular management of blood pressure. Many patients in China and other low- and middle-income countries miss out on this routine management.
- Policymakers should **embrace new technologies** to monitor risk factors, such as blood-pressure measurement devices linked to a communications device that transmits the data to a health centre.
- Ongoing **improvements in healthcare infrastructure** may be needed, even in the most developed countries. New technologies such as telemedicine enable the delivery of acute care to rural areas or the delivery of rehabilitation.
- **Improved access to healthcare**, including primary healthcare—particularly in low- and middle-income countries—is vital. In some cases, the cost of primary care is beyond the reach of local populations, meaning that they may avoid routine check-ups. A minority of patients in low- and middle-income countries continue with preventative

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drugs after a stroke, either because the drugs are not locally available or because they are too costly. Ensuring the availability of basic medication in many countries is critical to combatting stroke.

- **Progress in rehabilitation** is needed to help combat stroke. Currently, progress in rehabilitation lags behind progress made in stroke prevention and acute stroke treatment. Post-stroke rehabilitation that is convenient and affordable for patients and their families will be all the more effective in reducing the burden of stroke.

- Many health systems are in need of **clearly defined care pathways** from stroke prevention to rehabilitation. This includes looking for new and innovative ways of bringing patients through the full stroke care system in low-resourced areas.

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