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Understanding Stroke in a Global Context

Volume 2

Editor:
Shanthi Mendis

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Edited By

Shanthi Mendis
Geneva Learning Foundation, Former Senior Adviser
World Health Organization, Geneva, Switzerland

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PREFACE

Stroke is one of the most debilitating major noncommunicable diseases (NCDs). Increasing exposure to behavioural risk factors (tobacco use, unhealthy diet, physical inactivity and harmful use of alcohol) is intensifying the worldwide stroke and NCD burden. The burden of stroke is higher in low- and middle-income countries and, in particular, increasing in the younger age groups. Prevention and management of stroke have advanced a considerably over the last two decades. Scientific advances in the prevention and management of stroke have little value if they are not implemented worldwide. Implementation of new developments for the prevention and management of stroke depends on country resources and capacity that are closely linked to determinants of global health and development.

The world has reached a decisive point in recognizing the interdependence of global health and sustainable development. The agreed Sustainable Development Goals (SDGs), which replaced the Millennium Development Goals (MDGs) in 2015, can only be achieved with the absence of a high prevalence of debilitating diseases such as stroke and other NCDs. At the same time, actions to attain the Sustainable Development Goals can directly or indirectly contribute to reducing the stroke burden. The 17 Sustainable Development Goals relating to future international development include 169 targets to be attained by 2030. They cover a broad range of sustainable development issues, including NCDs. Furthermore, the world has also agreed on a time-bound set of nine voluntary global NCD prevention and control targets to be attained by 2025. The Sustainable Development Goals targets as well as the NCD targets are relevant to stroke. However, there is no clear agreement on *who should do what* to attain these ambitious targets at the country level. What is clear is that multiple actors in many sectors, including health, must work closely together to attain them.

This book is necessary because, at present, there is a serious disconnect between scientific progress in the field of stroke and implementation of these medical advances at the country level. The majority of countries do not adopt a sustainable public health approach to address stroke. A public health approach needs to combine prevention, treatment and monitoring components in order to tackle stroke in a cost effective and sustainable manner. Such an approach also needs to employ an integrated method to address stroke, recognizing that behavioural risk factors of stroke are also responsible for other major NCDs (heart disease, diabetes, chronic respiratory disease and cancer).

Stroke is the field of expertise of neurologists, but combating stroke is the business of everybody. The aim of this book is to introduce and increase the understanding of stroke as well as its links to the Sustainable Development Goals by decision-makers, policy-makers, lay people, journalists, public health practitioners, under-graduate and post-graduate students, and early career-level health professionals working in the fields of stroke, NCDs and development. All of them and others, have a role to play in prevention and control of stroke. A broader understanding of stroke by a wider audience can help to place stroke on the global development and health agenda and to strengthen country capacity to address stroke through a public health approach. There is a need for materials to help equip such interested parties to design, implement and evaluate strategies and programmes to address these diseases. The contents of this book are kept as simple as possible with this need in mind, particularly in the context of low- and middle-income countries.

This book is structured into eight chapters, each addressing key questions on various aspects of stroke. Chapter 1 covers causes, symptoms, signs and consequences of stroke. It has a different style and is much simpler, compared to other chapters, as the aim of this chapter is to

introduce stroke to those who have very little knowledge of the condition. Chapter 2 sets out an initial understanding of the sociopolitical and global health landscape, including the competing interests that can render stroke prevention challenging to governments. Chapter 3 discusses stroke and the burden it presents to low-, middle- and high-income countries. It goes on to explore the risk factors and prevention strategies of stroke. Chapter 4 presents the medical and surgical interventions available for managing stroke. Chapter 5 provides an update on the care of stroke, including stroke units, new therapies and future advances. Chapter 6 discusses the links between stroke and the Sustainable Development Goals and is based on information and data obtained from various United Nations documents on Sustainable Development. Chapter 7 presents data on the staggering economic burden of stroke and draws attention to the scarcity of data from the developing world which bears the major share of the global stroke burden. Finally, Chapter 8 summarizes the key messages in simple language. There is some unavoidable overlap between the chapters. The content has been simplified, to the extent possible, to provide better insight and understanding of stroke, particularly to a non-expert audience. It is, therefore, a "must read" for all those interested in stroke and global health.

Prof. Shanthi Mendis
Geneva Learning Foundation,
Former Senior Adviser World Health Organization,
Geneva,
Switzerland

List of Contributors

Bruce C.V. Campbell	Melbourne Brain Centre and Department of Neurology, Royal Melbourne Hospital, Melbourne, Australia
Stephen M. Davis	Melbourne Brain Centre and Department of Neurology, Royal Melbourne Hospital, Melbourne, Australia
Valery L. Feigin	National Institute for Stroke and Applied Neurosciences, Auckland University of Technology, Auckland, New Zealand
Graeme J. Hankey	Department of Neurology, School of Medicine and Pharmacology, The University of Western Australia, Perth, Australia Department of Neurology, Sir Charles Gairdner Hospital, Perth, Australia Australia Western Australian Neuroscience Research Institute (WANRI), Perth, Australia
Rita V. Krishnamurthi	National Institute for Stroke and Applied Neurosciences, Auckland University of Technology, Auckland, New Zealand
Peter Langhorne	Academic Section of Geriatric Medicine, Royal Infirmary, University of Glasgow, Glasgow, Scotland
Richard Lindley	University of Sydney, New South Wales, Australia
Shanthi Mendis	Geneva Learning Foundation, Former Senior Adviser World Health Organization, Geneva, Switzerland
Jeyaraj D. Pandian	Department of Neurology, Christian Medical College, Ludhiana, Punjab, India
Priya Parmar	National Institute for Stroke and Applied Neurosciences, Auckland University of Technology, Auckland, New Zealand
Akanksha G. Williams	Department of Neurology, Christian Medical College, Ludhiana, Punjab, India

CHAPTER 1

Stroke: Causes, Symptoms, Signs and Consequences

Shanthi Mendis*

Geneva Learning Foundation, Former Senior Adviser World Health Organization, Geneva, Switzerland

Abstract: A stroke occurs when blood flow to the brain is interrupted. The interruption may be due to build-up of fatty deposits on the inner walls of the blood vessels that supply blood to the brain (atherosclerosis and thrombosis), bleeding from a brain blood vessel (haemorrhage) or a blood clot that travels to the brain from a different part of the body (embolus). Cerebral thrombosis, cerebral haemorrhage and cerebral embolism are the three medical terms used to describe these three subtypes of stroke. Common symptoms of stroke include sudden weakness of the face, arm or leg, most often on one side of the body. Tobacco use, harmful use of alcohol, physical inactivity, unhealthy diet and air pollution are the main risk factors of atherosclerosis that lead to stroke. Noncommunicable Diseases (NCDs) (strokes, heart attacks, diabetes, cancer and chronic respiratory disease) share the same risk factors. Long-term exposure to these risk factors also cause raised blood pressure, diabetes and raised blood lipids, which increase the risk of developing strokes. The more risk factors a person has, the greater is the risk of stroke. Nearly two thirds of individuals who develop a stroke die or are disabled. After a first attack of stroke, medicines are required to prevent repeated attacks. Strokes are preventable if individual action is supported by health policies that reduce exposure of people to risk factors. Governments and political leaders have a vital role to play in the prevention of stroke and other NCDs through the implementation of public health policies to control tobacco use, harmful use of alcohol, unhealthy diet, physical inactivity and air pollution.

Keywords: Air pollution, Harmful use of alcohol, Heart attacks, Non-communicable diseases (NCDs), Physical inactivity, Stroke, Tobacco use, Unhealthy diet.

INTRODUCTION

This chapter addresses the following questions.

1. What is a stroke?

* **Corresponding author Shanthi Mendis:** Geneva Learning Foundation, Geneva, Switzerland; Tel/Fax: 0041227880311; E-mail: prof.shanthi.mendis@gmail.com

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2. Can stroke be prevented?
3. How does a stroke develop?
4. What factors increase the risk of a stroke?
5. What other diseases are caused by behavioural risk factors (tobacco use, harmful use of alcohol, unhealthy diet and physical inactivity)?
6. How does a stroke present?
7. What are the consequences of stroke?
8. How is a stroke diagnosed and treated?
9. Can you get repeated attacks of strokes?
10. What is stroke rehabilitation?
11. What can you do to reduce your risk of stroke?
12. What can you do if someone develops features of a stroke?
13. What can governments and political leaders do to improve prevention and care of stroke (NCDs)?

1. WHAT IS A STROKE?

If the blood flow to the brain is interrupted, the brain loses its supply of oxygen and glucose. This causes damage to the brain tissue that is known as a stroke. The World Health Organization (WHO) defines stroke as a clinical syndrome of rapid onset of focal cerebral (brain) deficit, lasting more than 24 hours (unless interrupted by surgery or death) with no apparent cause other than a vascular one [1].

The brain is a vital part of the nervous system that coordinates intellectual, motor and sensory functions of the body. The brain can only function if it is supplied with oxygen and nutrients through its blood supply. Two large blood vessels (known as carotid arteries), which run along either side of the neck, bring blood from the heart to the brain. The blood vessels known as arteries, branch off and become smaller and smaller, until tiny blood vessels supply oxygen, glucose and other nutrients to all parts of the brain (Fig. **1.1**).

Medical terms used to describe stroke include: cerebral haemorrhage; cerebral thrombosis; cerebral embolism; cerebrovascular disease; and transient ischaemic attack. These terms are not interchangeable as they describe different stroke subtypes.

2. CAN STROKE BE PREVENTED?

Stroke is a preventable disease. In 2012, an estimated 6.7 million deaths worldwide were due to stroke. More people die annually from strokes, heart attacks and other preventable diseases of blood vessels (cardiovascular diseases)

than from any other cause. Currently, about half (52%) of all premature deaths (deaths under age 70) in the world are due to stroke and other NCDs [2].

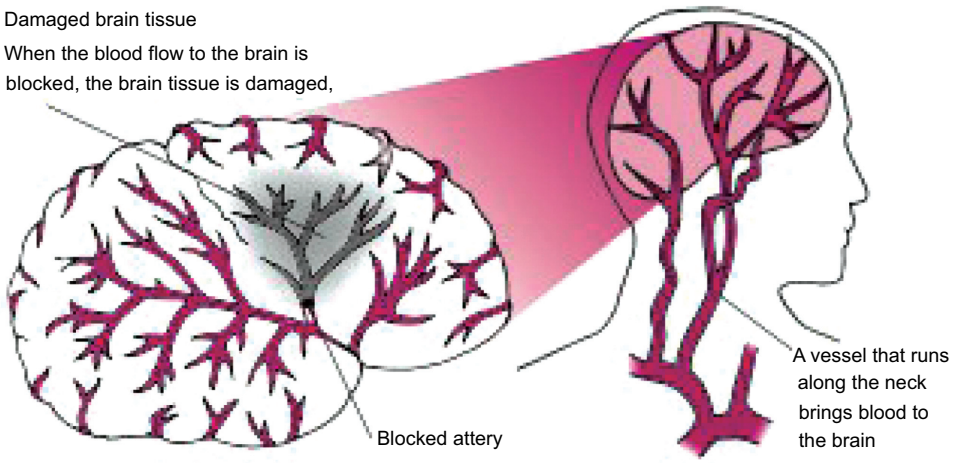

Fig. (1.1). A stroke happens when the blood supply to the brain is interrupted.
Source: Reprinted from Avoiding Heart Attacks and Strokes. World Health Organization. 2005.

Every year, in addition to 6.7 million people who die from stroke, many more millions are disabled due to strokes. Men as well as women, whether rich or poor, can suffer a stroke. Even when stroke patients have access to modern, advanced treatment, about two thirds die or become disabled. So it is important to know the warning signs and to act fast. But it is even better to prevent strokes from ever happening. Practically all the steps taken to prevent stroke can also prevent heart attacks, as the causative factors of these two diseases are very similar.

3. HOW DOES STROKE DEVELOP?

Strokes are caused by blockage in blood vessels that prevents the flow of blood to the brain. The most common reason for this is a build-up of fatty deposits on the inner walls of the blood vessels that supply the brain. This makes the blood vessels narrower and less flexible (Fig. **1.2**). This process is known as atherosclerosis. When a blood vessel becomes blocked by atherosclerosis the blood supply to an area of the brain is interrupted, and brain tissue is damaged resulting in a type of stroke known as an **ischaemic stroke.** Blood vessels affected by atherosclerosis can also rupture and bleed into the brain causing damage to brain tissue resulting in a type of stroke known as a **haemorrhagic stroke** (Fig. **1.3**). People with raised blood pressure are particularly vulnerable to this type of stroke. Haemorrhagic stroke may sometimes be due to structural abnormalities of blood vessels or brain tumours. Less commonly, blood vessels in

CHAPTER 2

Stroke, Politics, Global Health and Development

Shanthi Mendis*

Geneva Learning Foundation, Former Senior Adviser World Health Organization, Geneva, Switzerland

Abstract: At present, there is a serious disconnect between medical advances in the field of stroke and its worldwide application. Implementation of new advances to treat stroke depends on country resources and capacity. Stroke (NCDs) cannot be prevented if exposure to risk factors is ignored and action is taken only to provide high technology treatment for strokes. Prevention of first and recurrent attacks of stroke in high risk people through a primary health care approach and affordable stroke unit care for stroke victims need to be prioritized. Governments have a responsibility and a fundamental role to play in prevention by protecting people from exposure to tobacco, harmful use of alcohol, unhealthy food and air pollution. Effective implementation of policies to reduce exposure to behavioural risk factors and air pollution is challenging and is often influenced by politics. The tobacco, alcohol and food industries use devious tactics to protect profits at the expense of the health of people. The general public could lobby to support government policies that protect the health of people.

Keywords: Air pollution, Behavioural risk factors, Governments, Harmful use of alcohol, Non-communicable diseases (NCDs), Obesity, Physical inactivity, Public health policies, Stroke, Tobacco use, Unhealthy diet.

INTRODUCTION

This chapter addresses the following questions:

1. Why has the global burden of stroke (NCDs) got out of hand?
2. How powerful are the forces driving the stroke (NCDs) burden?
3. What are the tactics used by industry to undermine government policies to prevent stroke?
4. Do children and other vulnerable groups need protection from stroke (NCDs)?
5. Are governments doing enough to prevent childhood obesity?
6. What are the challenges that slow down the prevention and control of stroke (NCDs)?

* **Corresponding author Shanthi Mendis:** Geneva Learning Foundation, Geneva, Switzerland; Tel/Fax: 0041227880311; E-mail: prof.shanthi.mendis@gmail.com

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7. Is government action matching the size and complexity of the stroke (NCDs) burden?
8. What kind of country action is essential for the prevention of stroke (NCDs)?
9. What could governments do to reduce the exposure of people to behavioural risk factors of stroke (NCDs)?
10. How can health systems be strengthened for cost-effective prevention and control of stroke (NCDs)?
11. Does the global health and development milieu support action of governments?
12. Should governments be held accountable for inaction?

1. WHY HAS THE GLOBAL BURDEN OF STROKE (NCDS) GOT OUT OF HAND?

Major NCDs (stroke, heart attacks, diabetes, chronic respiratory disease and cancer) are diseases that are driven by profits, power, politics and demographic and epidemiological change. As discussed in Chapter 3, since 1990, there has been a steady increase in the absolute number of strokes, and the number of deaths from stroke. The global stroke (NCDs) burden has got out of hand due to inadequate attention to three modifiable causes. First, powerful forces that drive the stroke burden have been allowed to undermine public health policy using various tactics. Second, governments have failed to overcome these forces and implement multisectoral policies to reduce the exposure of people to behavioural risk factors (tobacco, alcohol, unhealthy diet and physical inactivity). Third, primary health care has not been strengthened for effective early detection and treatment of people at risk of developing stroke.

Exposure to behavioural risk factors can be reduced if governments take action to shape and regulate the social, economic and physical environments that people live in. Unhealthy behaviour causing stroke (NCDs) entails the use of strongly addictive substances such as tobacco and alcohol. A characteristic feature of addictive behaviour is the pursuit of immediate satisfaction at the risk of longer-term adverse outcomes. Consequently, people become addictive before they have an opportunity to exercise consumer choice. Although individual action is important for the prevention of stroke (NCDs), a supportive environment is critical for adopting and maintaining healthy behaviour.

2. HOW POWERFUL ARE THE FORCES DRIVING THE STROKE (NCDS) BURDEN?

The forces driving the stroke (NCDs) burden are very powerful. Globalization of marketing and trade has led to the dominance of large multinational corporations that make money from tobacco, alcohol and unhealthy food. Global governance is

weak and regulations are practically non-existent to match the growing power and influence of multinational corporations, which wield enormous economic and political influence and have massive marketing promotion budgets. For example, in 2008, the five major United States of America cigarette companies spent US$ 9.94 billion on marketing cigarettes in the country alone [1], an amount surpassing the gross domestic product (GDP) of at least 50 developing countries. Some of these countries still do not even have a dedicated unit within the Ministry of Health to address NCDs [2]. Most of the others have just one health professional to deal with the myriad challenges and complexities of handling the control of tobacco, alcohol and unhealthy diet. This unequal power and resource distribution has profound implications on national responses to combat NCDs in developing countries and makes it difficult for them to withstand industry tactics that undermine national law making. Not surprisingly, most low- and middle-income countries are lagging behind in developing and implementing policies to control unhealthy consumption behaviours [2].

Currently, the marketing strategies of the tobacco industry are primarily targeting vulnerable populations, including children and women. Their main focus is on less-developed countries with weaker regulatory frameworks [3]. More recently, the tobacco industry has even challenged the sovereign authority of states to protect health through tobacco control in Australia, Canada, India, Namibia, Nepal, Norway, the Philippines, South Africa, Sri Lanka, Togo, Turkey, the United Kingdom of Great Britain and Northern Ireland, Uruguay and the European Union [4 - 6]. In some of these countries, the tobacco industry is contesting pictorial health warnings and plain packaging as a tobacco control strategy, arguing that the packaging regulations impinge upon trademark and intellectual property rights. Some of these cases are pending. The majority of these governments, however, have won the legal battle to uphold national tobacco control measures. Behind most of these examples, there are courageous politicians who have put their political careers at risk to provide leadership to take on big tobacco. Former Health Minister Nicola Roxon of Australia, former President of Uruguay Tabaré Ramón Vázquez Rosas and Health Minister Rajitha Senaratne of Sri Lanka are three examples. There are many others (Table **2.1**). Courageous actions of such politicians should give other politicians greater confidence, conviction and courage to fight the tobacco menace.

The alcohol industry is also powerful. The value of alcohol marketing worldwide is estimated at US$ 1 trillion [7]. There is growing evidence that the alcohol industry is also using tactics somewhat similar to the tobacco industry to avoid any form of regulatory and legislative control [8 - 12].

CHAPTER 3

Global Stroke Burden and Stroke Prevention

Rita V. Krishnamurthi[1,*], Priya Parmar[1], Graeme J. Hankey[2] and **Valery L. Feigin[1]**

[1] *National Institute for Stroke and Applied Neurosciences, Auckland University of Technology, Auckland, New Zealand*

[2] *School of Medicine and Pharmacology, The University of Western Australia, Department of Neurology, Sir Charles Gairdner Hospital, Perth, Australia Western Australian Neuroscience Research Institute (WANRI), Perth, Australia*

Abstract: Population ageing and increasing exposure to behavioural and environmental risk factors are increasing the worldwide burden of stroke. Since 1990, there has been a significant increase in absolute numbers of strokes and the number of deaths from stroke. The burden of stroke is higher in low- and middle-income countries and, in particular, increasing in the younger age groups. The major risk factors for stroke are well established, and many of these, particularly behavioural risk factors such as tobacco use, harmful use of alcohol, unhealthy diet and physical inactivity, are modifiable. Hence, stroke is a highly preventable disease. Primary prevention is the key strategy for reducing the global health impact of stroke. This chapter presents the most recent updates from the Global Burden of Diseases, Injuries and Risk Factors Study (GBD) 2013 studies and discusses stroke prevention strategies.

Keywords: Carotid artery stenting, Carotid endarterectomy, DALYs, Epidemiology, Global Burden of Diseases, Global burden, Incidence, Injuries and Risk Factors Study (GBD), Low- and middle-income countries prevention, Mobile technology, Mortality, Prevalence, Stroke.

INTRODUCTION

This chapter addresses the following questions.

1. What is the current global disease pattern (epidemiology) of stroke?
2. Are there differences in low- and middle-income countries compared to high-income countries?
3. Are there differences in sex in stroke burden?
4. Why should stroke prevention be a priority?

[*] **Corresponding author Rita V. Krishnamurthi:** National Institute for Stroke and Applied Neurosciences, Auckland University of Technology, Auckland, New Zealand; Tel: +649 921 9999; Fax: +649 921 9260; E-mail: rkrishna@aut.ac.nz

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5. What are the current stroke prevention strategies?
6. What are the gaps in stroke prevention strategies and how can they be addressed?
7. What are the current surgical stroke prevention strategies?
8. What are the future directions in surgical prevention of stroke?

1. WHAT IS THE CURRENT GLOBAL DISEASE PATTERN (EPIDEMIOLOGY) OF STROKE?

The global impact of stroke is significant and rising. Stroke is the second major cause of death and the third leading cause of disability worldwide [1]. Its impact is felt on many levels; along with deleterious health-related consequences; stroke also has a major social, psychological and economic impact on the patients, their families and society [2]. The absolute numbers of strokes and the prevalence (the number of cases per 100 000 people studied) of stroke are projected to rise due to the ageing population of the world and exposure to risk factors. Due to the enormity of its impact, estimating and tracking its burden over time in terms of stroke incidence (rate of occurrence of new cases of stroke), prevalence, disability-adjusted life years (DALYs, a metric to describe years of healthy life lost) and mortality (death rate) worldwide and within countries and regions are eminently important. For example, if DALYs (in the context of stroke) for an individual equal to 10, it means that the individual lost 10 years of life free of disabilities due to stroke. Population wise, if DALYs equal to 100,000, it means that 100 000 years of life free of disabilities are lost due to stroke. Given that stroke is a heterogeneous disorder, it is also important to study the epidemiology of stroke by its subtypes – ischaemic stroke (due to the blockage of an artery supplying blood to the brain) and haemorrhagic stroke (due to the intracranial rupture of an artery supplying blood to the brain) – as the risk factors and outcomes of these two types of stroke may vary. Accurate and up-to-date estimates that also identify disparities in burden by countries and regions, race/ethnicity and sex allow health-care planning by governments and health ministries to allocate resources and manage the current and projected future burden. Importantly, stroke is a highly preventable disease by way of the adequate control of modifiable risk factors. The most effective way to reduce the impact of stroke is to prevent its occurrence in the first place (primary prevention) [3]. Therefore, identifying the prevalence and impact of modifiable risk factors (*e.g.* tobacco use, harmful use of alcohol, unhealthy diet and physical inactivity) is crucial for informing and planning the implementation of both current and novel prevention strategies.

Well-designed population-based epidemiological studies provide the most reliable source of information on current trends in stroke incidence, prevalence, DALYs

and mortality [4]. In countries that are resource poor, population-based stroke incidence studies may be too expensive to conduct. In these settings, the study of stroke prevalence using door-to-door surveys and the STEPwise approach to stroke surveillance (WHO STEPS-stroke) for studying stroke incidence facilitated by verbal autopsy data collection may be used as alternative sources of information [5]. Using all available observational data from various sources, the GBD studies provide a comprehensive picture of the current global burden of stroke, as well as temporal trends in age-standardized stroke incidence, prevalence, DALYs and mortality in 1990, 2005, 2010 and 2013 [6].

Worldwide Burden of Stroke

The first global estimates produced by the GBD 2010 showed that an estimated 16.9 million strokes occurred in 2010, with 69% of these occurring in low- and middle-income countries [7]. The study also showed that in 2010, stroke was the second-most common cause of death and the third-most common cause of DALYs in the world. Between 1990 and 2010, the global incidence of stroke increased slightly, but not significantly, while the prevalence of stroke increased significantly by 16%. Both DALYs and mortality rates declined significantly over this period. However, in terms of absolute numbers, incident stroke, prevalent stroke, DALYs and deaths increased globally by 68%, 84%, 12% and 26%, respectively, with the greatest increases seen in those aged 85 or older. In terms of the stroke subtypes, estimates from the GBD 2010 showed that globally in absolute numbers there were 11.6 million incident ischaemic and 5.3 million incident haemorrhagic strokes, with 2.8 million deaths from ischaemic stroke and 3 million deaths from haemorrhagic stroke [8]. There was a significant increase in the incidence rate of haemorrhagic stroke since 1990.

Trends in stroke burden differed between high-income and low- and middle-income countries. In high-income countries, stroke incidence declined significantly by 12%. In low- and middle-income countries, there was a significant increase in stroke incidence in the younger age group of 20–64 years of 18%. There was a significant increase in stroke prevalence in high-income countries of 27%. DALY rates were reduced in high-income countries by 36%, and low- and middle-income countries by 22%. Similarly, death rates declined significantly in both high-income countries by 37%, and in low-and middle-income countries by 20%.

GBD 2013 Findings

The GBD estimates of stroke burden were updated in the GBD 2013 study. These findings showed that stroke resulted in close to 6.5 million deaths in 2013, almost 2.5 million more than in 1990 [9]. Age-adjusted DALYs, incidence, prevalence

CHAPTER 4

Medical and Surgical Treatment of Stroke

Bruce C.V. Campbell[*] and **Stephen M. Davis**

Department of Medicine and Neurology, Melbourne Brain Centre at The Royal Melbourne Hospital, University of Melbourne, Melbourne, Australia

Abstract: Treatment of stroke patients should occur in dedicated stroke units with experienced medical, nursing and allied health staff to minimize morbidity and mortality. Specific treatment strategies depend on the type of stroke, which is determined by urgent brain imaging. The key treatment for ischaemic stroke, caused by a blocked blood vessel, is to restore blood flow using clot-dissolving medicine or minimally invasive surgery *via* angiogram. Both treatments are time critical as effectiveness reduces rapidly over the first few hours after stroke onset. Specific treatment options for intracerebral haemorrhage (bleeding into the brain) are limited, but lowering blood pressure may have some benefit and research into minimally invasive surgery is ongoing. In addition to lifestyle modification, prevention of further strokes requires lowering blood pressure and, for ischaemic stroke, lowering cholesterol and medications to reduce clotting (*e.g.* aspirin). Access to proven stroke therapies is highly variable and gaps lead to unnecessary disability, death and health costs.

Keywords: Cytoprotection, Intracerebral haemorrhage, Ischaemic stroke, Nanoparticles, Stem cell therapy, Stroke unit, Thrombectomy, Thrombolysis, Virtual rehabilitation.

INTRODUCTION

This chapter addresses the following questions.

1. What basic stroke care elements improve outcomes for a broad range of stroke patients?
2. What strategies that restore blood flow to the brain improve outcomes for ischaemic stroke patients?
3. Does surgical decompression improve outcomes for patients with large ischaemic stroke?
4. What medical interventions improve outcome in intracerebral haemorrhage?
5. What surgical interventions improve outcome in intracerebral haemorrhage?

[*] **Corresponding author Bruce C.V. Campbell:** Department of Neurology, Royal Melbourne Hospital, Parkville VIC 3050, Australia;; Tel/Fax: +61 3 9342 8448/+61 3 9342 8427; E-mail: bruce.campbell@mh.org.au

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6. Do strategies to reduce secondary injury (cytoprotection) improve outcome after stroke?
7. Who should take what action to improve the current situation/ gaps/ inequalities?

1. WHAT BASIC STROKE CARE ELEMENTS IMPROVE OUTCOMES FOR A BROAD RANGE OF STROKE PATIENTS?

Stroke Unit Care

Scientific studies (randomized controlled trials) of organized stroke care in a geographically defined stroke unit have demonstrated important reductions in morbidity (disease course) and mortality (death) compared to general medical care [1]. These benefits apply to all stroke subtypes, severities and demographic subgroups. The precise contributors to this effect are difficult to tease out, but are thought to include medical, nursing and allied health staff with specialist knowledge, interest and experience in managing stroke and preventing complications.

Prevention of aspiration pneumonia (lung infection due to food and oral secretions entering the airways when swallowing) with early swallow safety assessment is a key component. Nursing staff can often make an initial screening assessment of safety when trained with a validated screening tool. Speech therapist expertise can then be reserved for patients who fail screening, often due to the presence of a facial droop or a brainstem stroke that are associated with a higher risk of swallowing difficulties.

Patients with stroke are at high risk of deep venous thrombosis (DVT – clots in the veins of the legs) due to immobility and potentially fatal pulmonary embolism (migration of a clot to the lung where it can cause serious breathing problems and death). The use of pharmacological prevention of deep vein thrombosis (heparin or low molecular weight heparin) is generally recommended for patients with strokes due to blocked cerebral vessels (ischaemic stroke). Mechanical calf compression also has proven beneficial in reducing deep vein thrombosis and is particularly useful in patients with stroke due to bleeding in the brain (intracerebral haemorrhage) and ischaemic stroke patients at higher risk of bleeding complications such as in the first 24 hours after thrombolysis [2].

Early mobilization has been widely espoused, but a recent scientific study (the AVERT trial) demonstrated that ultra-early and intensive mobilization in the first 24 hours can be harmful for some patients [3]. The mechanism of this detrimental effect is not fully elucidated, but applied to both ischaemic stroke and intracerebral haemorrhage.

For some patients, especially those with pre-existing co-morbidities, stroke is their final illness. End-of-life care (palliation or comfort care) is an important component of stroke unit care that contributes to quality of life for patients and relatives.

Secondary Stroke Prevention (Preventing Recurrent Attacks of Stroke)

Those who develop a stroke are prone to repeated attacks of stroke. Appropriate secondary stroke prevention requires investigation for the cause of stroke. Essential investigations in ischaemic stroke include imaging the carotid arteries for strokes affecting that arterial territory and heart rhythm (ECG) monitoring to detect irregular heart rhythms.

Young stroke patients and those without traditional vascular risk factors require more intensive investigation to cover additional causes of stroke such as arterial dissection (a tear in the wall of an artery), which can be imaged with computerized tomography or magnetic resonance angiography, various heart abnormalities that can be screened for with ultrasound imaging (echocardiogram) and blood tests for clotting diseases. Patients with intracerebral haemorrhage should generally have arterial imaging to exclude underlying vessel abnormalities and follow-up imaging to ensure there is no lesion (such as a tumour) underlying the bleed. Venous sinus thrombosis (a clot in the veins draining the brain) also needs to be considered.

Blood Pressure

Blood pressure control is applicable to all stroke subtypes with no evidence of a lower threshold to target [4]. The level of blood pressure reduction appears to be more important than the specific agent used to achieve blood pressure lowering. Recent studies have confirmed observational evidence with blood pressure ~120 mmHg systolic associated with a lower cardiovascular risk than 130 mmHg or 140 mmHg systolic (although patients with a history of stroke were excluded from these studies and stroke itself was not significantly reduced) [5].

Antiplatelets and Anticoagulants

For ischaemic stroke in patients with normal heart rhythm, antiplatelet agents such as aspirin, aspirin-dipyridamole or clopidogrel are proven to reduce recurrent stroke. Combining aspirin and clopidogrel in the short term may be beneficial in high-risk patients [6]. The evidence in support of this came from a large Chinese trial where the diseased vessels were more commonly within the brain rather than in the neck vessels and more frequently affected Western populations. An ongoing trial is investigating short-term aspirin and clopidogrel in Western

CHAPTER 5

Stroke Care: Stroke Units, New Therapies, Advances and the Future

Jeyaraj D. Pandian[1,*], Akanksha G. William[1], Peter Langhorne[2] and **Richard Lindley[3]**

[1] *Department of Neurology, Christian Medical College, Ludhiana, Punjab, India*

[2] *Academic Section of Geriatric Medicine, University of Glasgow, Royal Infirmary, Glasgow, Scotland, UK*

[3] *University of Sydney, New South Wales, Australia*

Abstract: Thrombolysis (clot dissolving using medicine) and thrombectomy (clot removal *via* minimally invasive angiogram) are effective acute treatments for ischaemic stroke, but are expensive and time limited. Specialized stroke units are proven to manage stroke-related sequelae and complications effectively. They make stroke treatment quicker, easier and more accessible for a larger number of patients and have specialized staff, predefined protocols and better rehabilitation outcomes. These stroke units have proven benefits in countries that can afford them, but should be extended even to limited-resource settings when possible. Besides thrombolysis, thrombectomy and stroke unit care, ongoing research is exploring medications that may keep brain tissue in the region of a stroke alive for longer (cytoprotection), technological advances such as nanoparticles to increase the penetration of thrombolytic agents into the clot and stem cell therapies, all of which remain to be proven in large-scale randomized controlled trials. As a significant number of patients live with some level of disability, rehabilitation is important. Newer techniques to augment traditional rehabilitation such as robots and computer-based systems and virtual rehabilitation are some of the options currently being actively studied. These are easy to use and have shown positive results in small scale studies, but may be costly.

Keywords: Cost-effectiveness, Disability, Rehabilitation, Stem cell therapy, Stroke units, Thrombectomy, Thrombolysis.

INTRODUCTION

This chapter addresses the following questions.

1. What is the optimal care for stroke patients admitted in hospital?

[*] **Corresponding author Jeyaraj D. Pandian:** Department of Neurology, Christian Medical College, Ludhiana, Punjab, India; Tel/Fax: +91 161-2220850; E-mail: jeyarajpandian@hotmail.com

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2. What are the key components of stroke unit care?
3. What can be done to improve the quality of stroke services?
4. What action needs to be taken and by whom to address gaps in stroke care?
5. Can new technology increase thrombolysis in stroke patients?
6. Can technology be used in stroke rehabilitation?
7. Does stem cell treatment improve stroke outcome?

1. WHAT IS THE OPTIMAL CARE FOR STROKE PATIENTS IN HOSPITAL?

It is important to note that there is incomplete implementation of the key stroke treatments even in the developed countries of the world (Table **5.1**). Treatments such as thrombolysis and thrombectomy are expensive and may not be affordable for limited-resource settings. In countries with more limited financial resources, but with plentiful "human capital", stroke unit care and rehabilitation are likely to be more affordable. In addition, stroke unit care and rehabilitation are applicable to all stroke types, but thrombolysis and thrombectomy only for ischaemic stroke [1]. However, it should be noted that appropriate investment in acute treatments will reduce the requirement of rehabilitation so a balanced approach is required.

Table 5.1. Benefits of different treatment interventions for stroke.

Intervention*	Absolute Benefit (%)	Maximum Proportion Eligible (%)	Number of Extra independent Survivors per Year
Immediate aspirin	1	80	20
Stroke unit	5	80	100
Early community rehabilitation	5	35	44
Thrombolysis	7	20	35
Thrombectomy	25	10	62

* In order of increasing cost, thrombectomy being the most expensive.

In many countries, the standard pathway of care for stroke patients involves admission to hospital for initial assessment, diagnosis, treatment and rehabilitation. The aim of stroke services in hospital should be to provide the care that stroke patients and their families require and in the most efficient, effective, equitable, timely and humane possible manner. Several factors may influence the delivery of stroke care in hospital:

- effectiveness and cost-effectiveness of service design;
- local health-care economy and culture;
- views and needs of different patient groups; and

- resources available.

Stroke Unit

This is the key component of any stroke service and is the centre of stroke care within hospital. Recent publications have also termed these as “essential” stroke services [2]. The various components of stroke units are evidence based.

Primary Stroke Centre

A system of care providing services to a local area (note that recent publications have also termed these as “advanced” stroke services [2].

Comprehensive Stroke Centre

A system of care incorporating the full range of facilities required for regional stroke care in a high-income setting.

2. WHAT ARE THE KEY COMPONENTS OF STROKE UNIT CARE?

The primary objectives of a hospital-based stroke service are outlined in Fig. (**5.1**) and Table **5.2**.

Table 5.2. Objectives of stroke services.

Objectives	Proposed service options
Prompt and accurate assessment and diagnosis	Transport protocols
	Emergency department and hospital protocols
	Stroke centres
	Telemedicine networks
	Rapid access TIA clinics
Specific acute medical and surgical treatment	Stroke centres
	Telemedicine networks
	Stroke units
Identification and assessment of patients’ problems	Stroke units
	Stroke centres
	Telemedicine networks
Secondary prevention of further vascular events	Stroke units
	Stroke centres
	Rapid access TIA clinics
General care, including interventions to resolve problems (includes many aspects of rehabilitation)	Stroke units
Terminal care for patients who are unlikely to survive	Stroke units
Hospital discharge and reintegration into the community	Early supported discharge services
	Discharge planning
Long-term care for severely disabled patients	Outpatient rehabilitation services

TIA = transient ischaemic attack.

CHAPTER 6

Sustainable Development Goals and Stroke

Shanthi Mendis*

Geneva Learning Foundation, Former Senior Adviser, World Health Organization, Geneva, Switzerland

Abstract: The 2030 Agenda for Sustainable Development is an ambitious initiative of the United Nations, with 17 goals and 169 targets, integrating health, economic development, elimination of extreme poverty, social inclusion, environmental sustainability and good governance. The 17 Sustainable Development Goals focus on: poverty; hunger; health education; gender equality; water and sanitation; energy; economic growth and employment; industry, innovation and infrastructure; inequality; sustainable cities; consumption and production; climate change; marine resources; terrestrial ecosystems; peace, justice and accountability; and global partnership for sustainable development. There is a mutually reinforcing relationship between health and the three dimensions of sustainable development – social, economic and environmental. The connectors are health systems, behavioural, biochemical and environmental risk factors, ecosystems and the social and structural determinants of health, including enabling legal environments, financing and governance. In recognition of the negative impact of NCDs including stroke on development, they have been specifically incorporated in Goal 3 of the Sustainable Development Goals. Goal 3 addresses all major health priorities, including stroke and other NCDs, integral for the attainment of the Sustainable Development Goals. The 2030 Agenda for Sustainable Development, integrating health with economic, social and environmental dimensions of development, offers an unprecedented opportunity to address stroke (NCDs) and their determinants through multisectoral and multidimensional approaches.

Keywords: Accountability, Climate change, Consumption and production, Education, Employment, Energy, Gender equality, Health, Industry, Inequality, Infrastructure, Innovation, Justice, Marine resources, Millennium Development Goals, Noncommunicable diseases, Peace, Poverty, Stroke, Sustainable Development Goals, Sustainable cities, Terrestrial ecosystems, Water and sanitation, economic growth, hunger.

* **Corresponding author Shanthi Mendis:** Geneva Learning Foundation, Geneva, Switzerland; Tel/Fax: 0041227880311; E-mail: prof.shanthi.mendis@gmail.com

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INTRODUCTION

This chapter addresses the following questions.

1. What are the health-related Millennium Development Goals (MDGs)?
2. What is the 2030 Sustainable Development Agenda?
3. How are the Sustainable Development Goals linked to health and stroke (noncommunicable diseases)?
4. What are the 17 Sustainable Development Goals and 169 targets?

1. WHAT ARE THE HEALTH-RELATED MILLENNIUM DEVELOPMENT GOALS?

The eight Millennium Development Goals (MDGs), adopted in 2000, included three health-related goals: reduction in child mortality (Goal 4); reduction in maternal mortality and access to reproductive health care (Goal 5); and reversing the spread of HIV/AIDS, tuberculosis and malaria (Goal 6) [1]. These were instrumental in focusing global attention, development aid and national policies and resources in low- and middle-income countries on these important health issues [2, 3]. By 2015, unprecedented gains were made in combating malaria and tuberculosis, and providing access to antiretroviral medicines [4]. Although gaps remain in access to antenatal care and skilled birth attendance, in some parts of the world, considerable progress was made in the reduction of preventable infant and maternal mortality [4]. NCDs, (including stroke), were not included in the Millennium Development Goals and, therefore, received little global and national attention. In early 2000, bilateral aid for tackling NCDs dropped [5] despite their burgeoning contribution to the burden of global disease.

2. WHAT ARE THE SUSTAINABLE DEVELOPMENT GOALS (SDGS)?

The 2030 Agenda for Sustainable Development has merged the unfinished tasks of the Millennium Development Goals with the Agenda articulated in the 2012 United Nations Conference on Sustainable Development [5, 6]. It is an ambitious Agenda with 17 goals and 169 targets, integrating health, economic development, elimination of extreme poverty, social inclusion, environmental sustainability and good governance. While the Millennium Development Goals focused on low-income countries, the 2030 Agenda for Sustainable Development is universal and relevant to the whole world. The brief outline below on the Sustainable Development Goals and targets is based on information and data obtained mainly from United Nations documents.

3. HOW ARE THE SUSTAINABLE DEVELOPMENT GOALS LINKED TO HEALTH AND STROKE (NONCOMMUNICABLE DISEASES)?

The right to health is the most important fundamental human right [7]. According to the WHO definition: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". There is a reciprocal reinforcing relationship between health and all three aspects of sustainable development – social, economic and environmental. Action on the social and environmental determinants of health is in turn critical to creating inclusive, peaceful, equitable, economically productive and healthy societies [8]. The 2030 Agenda for Sustainable Development is based on this broader notion, extending it to incorporate other species, ecosystems and health risks. The health status of people is dependent on the wide-ranging and interlinked impact of social, economic, behavioural and environmental determinants, including biodiversity and ecosystems. The connectors are health systems, behavioural, biochemical and environmental risk factors, ecosystems and the social and structural determinants of health, including enabling legal environments, financing and governance [8].

The 2030 Agenda for Sustainable Development offers an unprecedented opportunity to address prevention and control of stroke (NCDs) from a multisectoral platform. In this context, to implement policies to effectively address stroke (NCDs), three strategic moves are required. First, governments need to reframe prevention and control of stroke (NCDs) from the disease model to embrace the multisectoral prevention model that underpins the 2030 Agenda for Sustainable Development. Second, health policy-makers need to emphasize and insist on health and health equity in all relevant policies of the agenda. The health sector needs to support and collaborate with other sectors to develop and implement policies and programmes in a way that optimizes co-benefits for all sectors involved [8, 9]. Third, health advocates need to engage with global governance structures to finance and implement the Sustainable Development Goals, including Goal 3 for health. The broad and interlinked nature of the Sustainable Development Goals make this repositioning more practical, feasible and indeed necessary.

4. WHAT ARE THE 17 SUSTAINABLE DEVELOPMENT GOALS AND 169 TARGETS?

4.1. Sustainable Development Goal 1

Sustainable Development Goal 1 calls for an end to poverty in all its forms by 2030. The international poverty line is currently defined at US$ 1.90 or below per person per day. In 2012, about 13% of the world's population was living below the poverty line [10]. If current growth rates prevail for the next two decades, the

CHAPTER 7

Economic and Societal Costs of Stroke

Shanthi Mendis*

Geneva Learning Foundation, Former Senior Adviser World Health Organization, Geneva, Switzerland

Abstract: Direct and indirect costs of stroke (NCDs) adversely impact macroeconomic productivity and national and household income pose a significant financial burden on health-care budgets. The estimated global economic loss due to cardiovascular disease (stroke and heart disease) has been estimated at US$ 863.5 billion in 2010. It is estimated to increase by 22% and to US$ 1.04 billion in 2030. For the period 2011–2025, the cumulative lost output in low- and middle-income countries associated with cardiovascular disease (stroke and heart disease) is projected at more than US$ 3.76 trillion. The total cost of implementing a set of very cost effective interventions for prevention and management of stroke across all low- and middle-income countries for the period 2011–2025, is estimated at only US$ 170 billion. This amounts to an annual per person investment of under US$ 1 in low-income countries, US$ 1.50 in lower-middle-income countries and US$ 3 in upper-middle-income countries.

Keywords: Cardiovascular disease, Cost-effective interventions, Direct costs, Economic burden, Household income, Indirect costs, Low- and middle-income countries, Macroeconomic productivity, National income, Stroke.

INTRODUCTION

This chapter addresses the following questions.

1. What is the magnitude of the economic burden of stroke globally?
2. What is the projected cost of stroke for low and middle income countries?
3. What is the impact of stroke on macroeconomic productivity?
4. What is known about the indirect costs of stroke?
5. What is known about the direct costs of stroke?
6. How do stroke costs impact on national health care expenditure?
7. What is the cost of treating an acute stroke?
8. What is the cost of atrial fibrillation related stroke?
9. What are the hospital costs of stroke based on population studies?

* **Corresponding author Shanthi Mendis:** Geneva Learning Foundation, Geneva, Switzerland; Tel/Fax: 0041227880311; E-mail: prof.shanthi.mendis@gmail.com

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10. What are the social costs and consequences of stroke?
11. What are the economic consequences of stroke on households?

1. WHAT IS THE MAGNITUDE OF THE ECONOMIC BURDEN OF STROKE GLOBALLY?

Stroke (NCDs) adversely affect economic growth through several pathways [1 - 7]. First, stroke exerts a negative macroeconomic impact through labour and productivity losses of affected people and their caregivers. Second, it drives up national health-care spending due to direct costs of medical care; and third, stroke increases out-of-pocket expenditures for households and contributes to impoverishment.

A study conducted by the World Economic Forum and the Harvard School of Public Health used three distinct approaches to compute the global economic burden of stroke (NCDs) for the period 2011–2030: (i) the standard cost of illness method; (ii) macroeconomic simulation; and (iii) the value of a statistical life [6]. These methods yielded results that are not comparable. Nevertheless, the estimates of this study give a sense of the current staggering costs and the growing economic burden of stroke (NCDs). To obtain a more reliable sense of the global cost of stroke more data are required particularly from low and middle income countries.

The cost of illness method looks at the cost of disease as the sum of several categories of direct and indirect costs. The estimated economic loss due to cardiovascular disease (stroke and heart disease), using this method was US$ 863.5 billion in 2010 (Table **7.1**) (an average per person cost of US$ 125) [6]. This loss is estimated to increase by 22% and to US$ 1.04 billion in 2030.

Table 7.1. Costs attributable to stroke and heart disease (cardiovascular diseases) in 2010 by WHO region. Source: Adapted from Bloom, D.E., Cafiero, E.T., Jané-Llopis, E., Abrahams-Gessel, S., Bloom, L.R., Fathima, S., Feigl, A.B., Gaziano, T., Mowafi, M., Pandya, A., Prettner, K., Rosenberg, L., Seligman, B., Stein, A.Z., & Weinstein, C. (2011). The Global Economic Burden of Noncommunicable Diseases. Geneva: World Economic Forum.

WHO Region	Total Costs (Including Productivity Costs) Billions of US$
Africa	11.6
Americas	303.1
Eastern Mediterranean	18.3
Europe	392.6
South East Asia	30.7
Western Pacific	107.1

(Table 7.1) contd.....

WHO Region	Total Costs (Including Productivity Costs) Billions of US$
Total	863.5

Overall, the cost for cardiovascular disease could be as high as US$ 20 trillion over the 20-year period 2011–2030. In 2010, about US$ 474 billion (55%) was due to direct health-care costs and the remainder (45%) to productivity loss due to disability and premature death or time loss from work due to sickness [6].

The economic growth approach estimates the projected impact of NCDs on total economic output (GDP) by taking into account how these diseases deplete labour and capital. Applying this approach over this 20-year period, the estimated loss due to cardiovascular disease (stroke and heart disease), was US$ 15.6 trillion (Table **7.2**) [6].

Table 7.2. Economic burden of cardiovascular diseases (stroke and heart disease) using macroeconomic simulation approach (trillions of US$ 2010) Source: Adapted from Bloom, D.E., Cafiero, E.T., Jané-Llopis, E., Abrahams-Gessel, S., Bloom, L.R., Fathima, S., Feigl, A.B., Gaziano, T., Mowafi, M., Pandya, A., Prettner, K., Rosenberg, L., Seligman, B., Stein, A.Z., & Weinstein, C. (2011). The Global Economic Burden of Noncommunicable Diseases. Geneva: World Economic Forum.

Country Income Group	Cardiovascular Diseases
High income	8.5
Upper-middle income	4.8
Lower-middle	2.0
Low	0.3
World	15.6

The value of the statistical life method reflects a population's willingness to pay to reduce the risk of disability or death associated with NCDs. Using this approach, the estimated loss from cardiovascular disease (stroke and heart disease), was US$ 8.3 trillion in 2010, increasing to US$ 15.8 trillion in 2030 [6]. Cardiovascular disease accounted for 33% of the lost output due to NCDs and mental health. The high-income countries bear the highest absolute burden of the lost output followed by upper-middle-income, lower-middle-income and low-income countries. By 2030, the upper-middle-income countries will take on a much bigger share of the economic burden due to the size and growth of their income and ageing of their populations, which are larger than those of high-income countries.

CHAPTER 8

Understanding Stroke in a Global Context – Key Points in Plain Language

Shanthi Mendis*

Geneva Learning Foundation, Former Senior Adviser World Health Organization, Geneva, Switzerland

The brain is a highly complex organ that requires a regular supply of glucose and oxygen for proper function. Glucose and oxygen are carried to the brain dissolved in blood that runs in blood vessels. Stroke occurs when the blood supply to a part of the brain is interrupted due to obstruction or rupture of a brain blood vessel. Blockage inside blood vessels is caused by accumulation of bad fat and cholesterol in their walls; a process known as atherosclerosis. Less commonly, obstruction to blood supply of the brain may be due to a blood clot that has originated in another part of the body such as the heart. Depending on the cause of interruption to blood supply of the brain, strokes are described as thrombotic, haemorrhagic or embolic.

Atherosclerosis develops due to unhealthy behaviour such as tobacco use, harmful use of alcohol, lack of regular physical activity and consumption of unhealthy diets. Diet is unhealthy when it is too rich in salt, fat and energy (calories) and lacks fruits, vegetables, minerals and fibre. Exposure to polluted air also increases the risk of atherosclerosis.

Unhealthy behaviour results in overweight, obesity, high blood pressure, diabetes and high cholesterol levels in blood. These are additional risk factors that promote atherosclerosis, which leads to stroke.

Stroke is a common illness of the brain that can affect any adult, usually after middle age. Strokes often result in severe disability or death. Strokes are preventable if individual action is supported by public health policies that reduce exposure to risk factors of stroke.

Worldwide, stroke is the second leading cause of death and the third leading cause of disability. Globally, the majority of strokes (70%) and stroke-related deaths

* **Corresponding author Shanthi Mendis:** Geneva Learning Foundation, Geneva, Switzerland; Tel/Fax: 0041227880311; E-mail: prof.shanthi.mendis@gmail.com

Shanthi Mendis (Ed.)
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(87%) occur in low- and middle-income countries. Over the last four decades, the occurrence of stroke (incidence) has more than doubled in low- and middle-income countries, while it has declined in high-income countries.

Strokes, heart attacks, diabetes, cancer and chronic respiratory disease are known as major non-communicable diseases (NCDs). They are caused by the same behavioural and environmental risk factors: tobacco use; harmful use of alcohol; physical inactivity; unhealthy diet; and air pollution. The more risk factors a person has, the greater the risk of strokes and other NCDs. Often people are affected by more than one NCD. For example, stroke and diabetes often occur together because they share the same risk factors.

Power, profit and politics are forces that drive the exposure of people to tobacco use, harmful use of alcohol, physical inactivity and unhealthy diet.

Governments have the responsibility and a fundamental role to play in protecting people from exposure to behavioural and environmental risk factors. Supportive policy environments make healthy choices and behaviours easier, and unhealthy choices and behaviours more difficult.

To prevent stroke (NCDs), people need to be protected from exposure to behavioural and environmental risk factors through strong public health policies. For example, policies to control tobacco and alcohol use, conducive environments for physical activity and affordable fruits and vegetables promote healthy behaviour. Most of these policies require action from ministries outside of the Ministry of Health such as ministries of finance, trade and agriculture.

Individual action is extremely important and people need to adopt healthy behaviour. Undoubtedly behaviour change is difficult and challenging, but there is a greater chance of people maintaining healthy behaviours if they are in conducive regulatory, legislative, economic and physical environments.

Too often actors with vested interests undermine the development and implementation of public health policies that reduce the exposure of people to risk factors of stroke such as tobacco, alcohol, unhealthy diet and physical inactivity. The tobacco, alcohol and food industries consistently use devious tactics to protect profits at the expense of the health of people. Governments and political leaders are responsible for protecting the development and implementation of these policies from parties with vested interests. Civil society should lobby and support governments to develop and implement policies that protect the health of people.

Standards of prevention and care for stroke (NCDs) depend on financial and other resources. Standards of health care for stroke vary tremendously in different countries depending on the level of economic development.

Health systems have a key role in prevention, acute care and rehabilitation of stroke. To prevent the first attacks of stroke, people at high risk of stroke need to be identified in primary care and provided treatment. The detection of people at high risk simply does not happen in countries with weak primary care systems.

In addition, most low-income countries do not have facilities to deliver acute stroke care. Stroke patients must be rapidly identified and transported to appropriate centres that provide optimal treatment as fast as possible.

Nearly two thirds of individuals who develop a stroke either die or are disabled. The chances of dying are much higher with subsequent strokes, which often occur within one year of the first attack. After the first attack of stroke, medicines are required to prevent repeated attacks.

Improving stroke services and treatment can have a major impact on patient outcomes. Hospital-based stroke units can benefit most stroke patients and could be widely implemented. Ideally, all stroke patients would be admitted directly to a stroke unit.

Acute stroke management practice in low-resource settings needs to include supportive care measures such as maintaining the control of blood pressure, blood sugar, body temperature, prevention of clot formation in leg veins and aspiration, and early mobilization and prompt treatment of fits.

Although stroke treatment has advanced significantly over the last two decades and highly effective interventions exist that reduce disability after a stroke, they require much broader implementation to maximize benefit. The majority of stroke victims worldwide currently have no access to high technology stroke interventions because of weak health systems. For patients to benefit from advances in therapy, technology must be embedded in systems that allow rapid treatment because stroke progresses quickly in the first few hours after onset. At present, there is a serious disconnect between advances in the field of stroke and its worldwide application. Most low-income countries do not invest enough in health care to enable implementation of new medical advances for the treatment of stroke such as clot busting therapy.

Stroke (NCDs) cannot be prevented if action is taken only to provide health care for strokes, while exposure to risk factors is ignored. A public health approach to stroke needs to combine policies to reduce exposure to behavioural and

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Shanthi Mendis

Professor Shanthi Mendis is a specialist in Internal Medicine, Cardiology and Public Health. She is an independent Consultant in Global Health and a Trustee of the Geneva Learning Foundation. She served the World Health Organization (WHO) as Senior Adviser, Non-Communicable Diseases (NCD) and in other senior capacities for 20 years. She was Professor of Medicine, Faculty of Medicine, Sri Lanka when she joined the WHO on a Rockefeller Global Health Leadership Fellowship. During her tenure in WHO she led and supervised the development of many seminal products in NCD including the global action plan (2013), the global report (2014) and many global conferences and technical guidelines. She also developed an innovative Package of Essential NCD interventions (WHO PEN) to strengthen primary health care policy in developing countries. After completing internship in Bristol, England, she practiced medicine in the UK and USA. She is a Fellow of the Royal College of Physicians of London and Edinburgh and a Fellow of the American College of Cardiology. She was awarded National Honours (Sri Lanka) for contribution to Medical Research in 2005. In 2014 she was elected to life-membership of the World Stroke Association. In a medical career spanning 42 years, she has gained extensive experience in Global Health, Medical Education and Research. She has co-authored 3 books, many book chapters, and published over 150 papers in peer-reviewed, International Journals.