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Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

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SUPPLEMENTARY MATERIALS – Table of Contents

OVERVIEW OF METHODS

After reviewing results from the survey and review of stroke guidelines,[1-3] we also performed a review of relevant literature on interventions for stroke. To guide and direct the actions of the Commission, a conceptual framework was developed (Figures 1-3 in the manuscript). For each step there were predefined activities as follows:

1. Situational and Gap analysis
    1.1. Situational analysis including stroke burden (deaths and DALYs) forecast from 2020 till 2050 (GBD Study).
    1.2. Stroke rehabilitation services/settings (tele-rehabilitation, home based, community based).
    1.3. National, regional and global stroke control targets, strategic plans, and KPIs in roadmaps and pragmatic guidelines, synergy with WHO and UN NCD SDG initiatives and 2030 targets as well as Universal Health Coverage.
    1.4. Rank countries according to performance scores in stroke surveillance, prevention, acute care, and rehabilitation.
    1.5. Identification of success stories in various settings that can be leveraged across the globe.
    1.6. Gap analysis and priority setting. Key Informant Interviews (WSO funded thematic analysis).
2. Evidence-based interventions
    1.1. Evidence-based practice recommendations based on synthesis of evidence-based guidelines and emerging RCTs and meta-analyses based on systematic evidence-to-decision methodology including Grading quality of evidence and strength of recommendations (GRADE)[4] (non-pharmacological, pharmacological, surgical, rehabilitation etc.).
3. Implementation science framework
    1.1. Behavioural change wheel[5]
    1.2. Co-production and co-implementation of political, legal, ethical, sociocultural, and economic framework. Advocacy using economic case and political case.
4. Pragmatic solutions, targets, ecosystems, key performance indicators, and future directions
    1.1. Pragmatic solutions will be presented with dedicated sections for global, regional and LMIC contexts.
    1.2. Implementation science ecosystem. WSO Task Force on Stroke in synergy with NCD control initiatives, World Heart Federation (WHF), Global Coalition for Circulatory Health, European Stroke Organisation (ESO), World Federation for Neurorehabilitation (WFNR). WHO Rehabilitation 2030 Initiative in synergy with local, national, and regional actors, plans and strategies (e.g., AHA/ASA, AAN, MENASO, ESO, ASO, NGOs- NCD Alliance, UNGA, World Health Assembly [WHA], Resolve To Save Lives, World Bank, OneNeurology, Angels Initiative for spreading acute care -covering >6000 hospitals in >140 countries, MT2020 + GEC [for spreading mechanical thrombectomy], etc.). Increase the number of Commissioners for global coverage.
    1.3. Interactions with WHO and WHA, and Ministries of Health.
    1.4. Support from and/or partnership with the World Bank and other major charity organizations, philanthropists.
    1.5. Innovations: digital solutions, social media, Artificial Intelligence, trans-omics, social marketing, applied theatre, life-course multi-sectoral approach, tele-health, data science, precision public health, success stories, mobile phone apps for surveillance, prevention, tele-rehab, acute care connections; Interactive websites etc.

1.6. Policy briefs.
1.7. Presentation and launching at the World Stroke Congress in October 2023.
1.8. Others - Bellagio meeting and agenda for August/September 2023, timelines, and deliverables.

Priority Setting

At this stage, we identified key recommendations with the highest grade of evidence from best quality stroke guidelines. The guidelines utilized were those which fulfilled the criteria proposed by the Institute of Medicine standard;[6] comprehensively covered a wide spectrum of stroke services; were regularly and recently updated; with targeted audience including healthcare providers, patients, policy makers, and the populace; and/or were international or regional.

These include recommendations of the leading high quality global evidence-based stroke guidelines from three continents and several major stroke organizations: the American Heart Association (e.g., Class I Level A),[7] Netherlands KNGF Stroke Guideline,[8,9] Canada Stroke Best Practice recommendation,[10] European Stroke Organisation,[11] Australian Stroke Foundation,[12] New Zealand Stroke Foundation,[13] National Institute for Health and Care Excellence (NICE) guidelines for stroke,[14] and World Stroke Organization.[15] From these top quality guidelines, we selected and prioritized only consistent recommendations with the best grade of evidence. We indicated the level of evidence for each selected recommendation according to the evidence level assigned by the stroke guidelines.

Contextualization

At this stage, for each guideline-derived recommendation selected, we considered the ethical, legal, sociocultural, and economic implications, anticipated and observed barriers and facilitators for its implementation within the framework of the implementation cycle. This cycle includes a contextualization and dissemination plan to all stakeholders (providers, practitioners, policy makers, payers, populace, implementation partners).[16-18] The contextual barriers and facilitators were derived from the situational analysis provided by the surveys and systematic reviews as well as narrative review of relevant literature.

Solutions and Research Gaps

This stage involved synthesis of pragmatic solutions to overcome barriers and amplify facilitators for practical implementation of the selected evidence-based recommendations. Whenever evidence-based recommendations were not available to address certain clinical needs, the evidence and research gaps were noted. Furthermore, the financial costs of stroke were estimated and an economic case for stroke prevention, acute care and rehabilitation developed.

A follow-up assessment will be conducted with an updated report to estimate the possible impact of the Commission's recommendations on changes to stroke services in three to five years. Over the years, we will also monitor the trend of stroke burden – incidence, prevalence, mortality and DALYs through the GBD and other sources.

Innovation

Pragmatic interventions to achieve the WHO NCD targets should follow these four cardinal recommendations:

1. Synergistic actions should be coordinated based on an implementation science theory[5] which can be adapted to harmonize, synchronize, and synergize all action items in the roadmap.
2. Develop a sustainable multisectoral interdisciplinary implementation ecosystem (at international, regional, national, and subnational levels -macro [legal, regulatory, and economic barriers and enablers], meso [local health services and community factors] and micro [day-to-day practice] levels) that informs, Inspires, collaborates with, and empowers all stakeholders to act towards achieving the targets under the leadership of the WSO Task Force on Stroke.
3. Use an Integrated NCD approach addressing surveillance, prevention, acute care, and rehabilitation across the life-course.
4. Use the principle of the iterative implementation cycle to navigate barriers and enhance facilitators to deliver impact through effective communication with and participation of all stakeholders.

Strengths

The pragmatic solutions offered were based on prioritization of evidence-based recommendations from high quality stroke guidelines derived from a systematic review of stroke guidelines across the globe. Contextualization to facilitate implementation in low- and middle-income settings was informed by the data from the situational analysis which identified the service gaps and barriers. The proposed ecosystem for synergistic action is the global stroke control observatory and risk reduction ecosystem, the components and interactions of which we illustrated in Figures 1-3 of the manuscript. In addition to this proposed ecosystem for synergistic action, as well as the dissemination and implementation plans, we provided an economic case to support the implementation of the solutions as well as policy briefs to engage policy makers.

STROKE BURDEN PROJECTIONS

Methods used to forecast stroke burden

The methodology for determining stroke types has been reported elsewhere.[19] Forecasts of stroke burden were produced from cause-specific GBD 2019 estimates of mortality, incidence, and prevalence for IS, ICH and SAH.[19,20]

Mortality rates for each individual cause were forecasted using a three-component model comprised of: (1) the underlying (or risk deleted) mortality, modelled as a function of the socio-demographic index (SDI)[21] and time; (2) a risk factor scalar that captures cause-specific combined risk factor effects based upon the GBD comparative risk assessment, which quantifies risk-outcome associations accounting for risk factor mediation; and (3) unexplained residual mortality. Additional modelling details are described in Foreman et al.[22] and Vollset et al.[23] The risk factor scalars for each of the stroke sub-causes (ICH, SAH and IS) were comprised of the following individual risk exposure forecasts: alcohol use, poor diet quality, air pollution (household and particulate matter), high body mass index, high fasting plasma glucose, lead toxicity, impaired kidney function, high systolic blood pressure, and non-optimal temperature.

Forecasts of disability-adjusted life-years (DALYs) lost were produced from forecasts of years of life lost (YLLs; via mortality) and years lived with disabilities (YLDs; via prevalence and incidence). Forecasts of incidence for IS, ICH and SAH were modelled using a linear mixed-effects model (the mortality-incidence ratio) and used forecasted mortality to convert to incidence and prevalence (not reported

in this manuscript but used for estimating projections of DALYs). This was to allow the forecasts of risk exposure (via the risk factor scalar) to also drive the subsequent forecasts of incidence and prevalence. Prevalence forecasts for ICH and SAH were modelled using a modelled prevalence-incidence ratio, while IS prevalence was modelled directly.

Mortality-incidence and prevalence-incidence ratios were modelled as:

$$\log\left(R_{a,s,l,y}\right) = \beta_0 + \beta_1 SDI_{l,y} + \pi_{0:a,s,l} + \pi_{1:a,s,l} SDI_{l,y} + \varepsilon_{a,s,l,y}$$

where $R_{a,s,l,y}$ is the age-sex-location-year specific ratio for a given cause, with the covariate $SDI_{l,y}$ being the location-year specific SDI. $\pi_{0:a,s,l}$ is the age-sex-location specific random intercept, $\pi_{1:a,s,l}$ is the age-sex-location specific slope on SDI, and $\varepsilon_{a,s,l,y}$ is the residual term. A shift in log space was applied to each age-sex-location combination after prediction to align the value of the modelled value in the last year of GBD estimates with the GBD estimate for that year.

Prevalence of IS was modelled as:

$$\text{logit}\left(P_{a,s,l,y}\right) = \beta_0 + \beta_1 SDI_{l,y} + \pi_{0:a,s,l} + \varepsilon_{a,s,l,y}$$

where $P_{a,s,l,y}$ is the age-sex-location-year specific prevalence of a given cause, with location-year specific SDI as the covariate for the fixed slope and $\pi_{0:a,s,l}$ as the age-sex-location specific random intercept.

Once forecasts of prevalence for all causes were obtained, they were converted to YLD using average disability weights calculated as the YLD divided by prevalence in 2019. The YLL were computed by multiplying the number of deaths by the reference life expectancy at the age of death. Forecasts YLLs were computed from forecasted age-sex-location-specific mortality rates and GBD reference life table.[19] Future YLLs and YLDs were then added together to obtain forecasts of DALYs.

Forecasts of all measures were produced by age and sex at the national level and are aggregated using population to global and regional estimates. Population forecasts are produced as described in Vollset et al.[23] All projected estimates are reported with 95% uncertainty intervals (UI).

THEMATIC ANALYSIS METHODS

Setting

We used a multiple case study approach to gain an understanding of the barriers and facilitators to high-quality stroke services across the world. Multiple case studies allow consideration of an area from multiple perspectives.[24] The aim was to identify gaps and pragmatic solutions to address the broader goals of the WSO – The Lancet Neurology Commission on Stroke.

Qualitative data

Qualitative data was captured in interviews conducted by researchers with expertise in stroke and qualitative methods. Interviews were conducted by three interviewers (SG, TPN, EU) from July to September 2022 via online web conferencing software and recorded. A semi-structured interview guide was used for interviews (see appendix). Questions explored characteristics of the services based on health system building blocks of service delivery, workforce, information, technology, financing, and governance.

Participating countries

Participating countries were identified from the State of Stroke Services survey[2] conducted by the WSO with involvement of some members of the Operations Committee of the WSO – The Lancet Neurology Commission on Stroke. Key informants who spoke English and were from countries with exemplars of 'acceptable', 'good' or 'very good' activities across surveillance, prevention, acute care, and rehabilitation sections were invited to participate. In the context of the State of Stroke Services Survey, scores of 30% to <50% were determined as acceptable, 50% to <75% were determined as good and 75% to 100% were determined as very good. We used purposeful sampling to obtain exemplars from two countries in each World Health Organisation (WHO) region that perform well with scores at least 30% across multiple sections, with one higher income and the one lower income country. When there were many potential countries that met the criteria, we used a random number generator to select a country.

Recruitment strategy

We aimed for 2 countries per WHO region (African region, Eastern Mediterranean region, European region, region of the Americas, South-East Asia region, and Western Pacific region) for the stroke prevention, acute care and rehabilitation sections of the manuscript. From our purposeful sampling of countries with high performance across sections, we created a 'contact' list of countries with each region having 2 primary and 2 alternate contacts. If a respondent for a 'primary' country was unable to be identified, we use 'alternative' contacts from the list. We initially invited commissioners who completed the WHO-WSO quantitative survey to participate in the interviews. Once a potential participant was identified, the research team contacted these potential participants via email explaining the study. If participants were interested, they were sent a 'Participant Information Pack' including a cover letter, the questions for the interview, the information sheet and consent form before the interview. All participants provided written informed consent prior to interviews.

Data Collection

The virtual interviews were estimated to take between 45-60 minutes. Identifying information of the respondent was not gathered as part of the interviews. We used an identification code to link interviews across countries. Identifiable information such as name were not collected during the interview and participant/country identities were not identifiable in analyses or outputs.

Data Analysis

We conducted a within-case analysis for interviews from each country survey using a pre-developed coding matrix. The coding matrix consists of two dimensions: health system building blocks (workforce, finance, services, technology, information, and governance) and the impact of a factor (barrier/facilitator).

This was followed by a thematic analysis across countries/services to identify similar patterns in the facilitators or barriers associated with good stroke services. Two researchers conducted thematic analysis for separate areas of stroke services (SG – rehabilitation and acute care; TPN – prevention and surveillance). Analyses were conducted using NVivo.

Funding

The study was supported by funding from the World Stroke Organization and Synergies to Prevent Stroke (STOPstroke, GNT1182071).

Ethics

The thematic analysis study was approved by the Tasmania Health and Medical Research Ethics Committee (H027312).

Results

We contacted potential interviewees for 12 countries identified as 'primary' contacts using the sampling frame. Of these, the primary contacts agreed to participate for 7 countries. We contacted 'alternate' contacts for the remaining countries with an additional 4 agreeing to participate. The final participants came from each WHO region with a good distribution of income regions noting that not all interviews across all sections were able to be completed due to non-response of suggested interviewee. There were 34 interviews in total covering all sections across all WHO regions and high (n=3), upper middle (n=3) and low (n=6) income countries.

Table 1. Interviews completing within sampling framework by WHO region and income level showing total interviews within sections and within countries

WHO region	Country #	Income level	Surveillance	Prevention	Acute Care	Rehabilitation	Total
African Region	1	LI	1	1	1	1	4
African Region	2	LMI		1	1	1	3
Region of the Americas	1	LMI			1		1
Region of the Americas	2	HI	1				1
Eastern Mediterranean Region	1	UMI	1	1	1	1	4
Eastern Mediterranean Region	2	LMI	1	1	1	1	4
European Region	1	HI	1	1	1	1	4
European Region	2	LI	1	1			2
South-East Asian Region	1	LMI	1	1	1	1	4
South-East Asian Region	2	UMI			1		1
Western Pacific Region	1	HI	1	1		1	3
Western Pacific Region	2	UMI	1	1	1		3
Total			9	9	9	7	34

Appendix

Semi-structured interview guides

Numbered questions were sent to interviewees prior to interview with prompts held by interviewer if initial responses did not illicit the necessary information.

Acute care

Question 1 - Can you describe the acute stroke services in your country?

Prompts

- Can you describe the general structure of the health care system in your country? e.g., public versus private, state or federal management of hospitals.
- What are the standard components of acute stroke care that are provided? e.g., imaging including CT or advanced neuroimaging, tPA, clot retrieval, stroke units, specialized stroke nurses, paramedic pre-hospital stroke screening.

- What protocols or guidelines are in place for acute stroke treatment? e.g., national guidelines, hospital level guidelines, international guidelines.
- How equitable is the delivery of these services across the country? e.g., differences between urban and rural, transfer protocols, hub and spoke networks.

Question 2 - Can you describe the workforce for acute stroke care?

Prompts

- What types of training and skills do people working in acute stroke care have? e.g., physician training, specialized training in stroke, overseas fellowships, specialized nursing education as undergraduate or postgraduate.
- What types of strategies are there to attract or retain people to work in acute stroke care in your country? e.g., undergraduate or post-graduate training, research fellowships.
- What works well with your workforce for acute stroke care in your country?
- What isn't working well with your workforce for acute stroke care in your country?

Question 3 - How is acute stroke care funded in your country?

Prompts

- Can you describe how different levels of government might fund acute stroke care? e.g., state or federal funding; universal health care
- How are private organizations involved in funding acute stroke care? e.g., private health insurance, private hospitals, employer programs.
- What do you think about the level of funding that is provided for acute stroke care?
- What works well with funding for acute stroke care?
- What isn't working well with funding for acute stroke care?

Question 4 - How is technology used for acute stroke care?

Prompts

- Can you describe the role of technology in acute stroke care? Could include electronic medical records, telehealth, advanced neuroimaging.
- What are the barriers to using technology in acute stroke care?
- What facilitates your use of technology for acute stroke care?

Question 5 - What is the role of information or data in your delivery of acute stroke care?

Prompts

- What are the sources of data to monitor levels of acute stroke care? e.g., hospital-based surveys, clinical quality registries.
- What is the coverage of data on acute stroke care like?
- How are these data used for audit and feedback or quality improvement initiatives?
- How is the collection of these data funded?
- What are the things that work well with using information or data for acute stroke care?
- What are the things that don't work well in terms of information or data for acute stroke care?

Question 6 - What are the governance processes you have around acute stroke care?

Governance processes may include a wide range of components, including ethics, policies, frameworks/procedures, guidelines, risk management, and administration around stroke surveillance.

Prompts

- Who is responsible for the coverage and quality of acute stroke care in your country? e.g., national standards on hospital care, federal or state governments.
- What are the frameworks or guidelines for acute stroke at a local, national or regional level?
- What types of advisory groups are responsible for monitoring or improving acute stroke care in your country? Do these operate at a national, regional or hospital level?
- What is the role of accreditation of health professionals or hospitals to provide different levels of stroke care? e.g., body that accredits comprehensive or primary stroke centres; body for accrediting neurologists for stroke care; credentialing of neuroradiologists.
- What works well with the governance of acute stroke care?
- What isn't working well with the governance of acute stroke care?

Question 7 - Is there something else you would like to say, that we have not talked about in the interview?

Prevention

Question 1 - Can you describe the services for the primary and secondary prevention of stroke in your country?

Prompts

- What are the services for the primary prevention of stroke? e.g., annual health checks with general practitioner or primary care doctor; community screening of risk factors; awareness campaigns for risk factors (e.g., smoking, blood pressure); government policies or laws – e.g., tobacco control; obesity or diet strategies; absolute cardiovascular risk assessment.
- What are the services or programs for secondary prevention? e.g., in-hospital risk factor education; routine use of discharge medications; connections with primary or community care; specific programs for risk factor modification run by the hospital or community organisations.
- What protocols or guidelines are in place for primary prevention of stroke? e.g., national guidelines, hospital level guidelines, international guidelines.
- What protocols or guidelines are in place for secondary prevention? e.g., national guidelines, hospital level guidelines, international guidelines.
- How equitable is the delivery of these services across the country? e.g., differences between urban and rural; transfer protocols, hub and spoke networks.
- Can you describe the general structure of the health care system in your country? e.g., public versus private, state or federal management of hospitals.

Question 2 - Can you describe the workforce for stroke prevention?

Prompts

- What types of training and skills do people working in primary prevention have? e.g., general practice, nursing, pharmacy, community health workers.
- What types of training and skills do people working in secondary prevention have? e.g., general physicians, neurologists, general practice, nursing, pharmacy, community health workers.
- What works well with your workforce for stroke prevention in your country?
- What isn't working well with your workforce for stroke prevention in your country?

Question 3 - How are stroke prevention activities funded in your country?

Prompts

- Can you describe how different levels of government might fund primary prevention activities? e.g., state or federal funding, universal health care, user pays, private health insurance, non-government organisations.
- Can you describe how different levels of government might fund secondary prevention activities? e.g., state or federal funding, universal health care, user pays, private health insurance, non-government organisations.
- What do you think about the level of funding that is provided for primary prevention?
- What do you think about the level of funding that is provided for secondary prevention?
- What works well with funding for stroke prevention?
- What isn't working well with funding for stroke prevention?

Question 4 - How is technology used for stroke prevention?

Prompts

- Can you describe the role of technology in stroke primary prevention? Could include telehealth, risk assessment tools, digital health, e.g., apps like Stroke Riskometer, online information.
- Can you describe the role of technology in stroke secondary prevention? Could include electronic medical records, telehealth, risk assessment tools, digital health, online information.
- What are the barriers to using technology in stroke prevention?
- What facilitates your use of technology for stroke prevention?

Question 5 - What is the role of information or data in stroke prevention?

Prompts

- What are the sources of data to monitor primary or secondary prevention? e.g., hospital-based surveys, clinical quality registries.
- What is the coverage of data on secondary prevention?
- How are these data used for audit and feedback or quality improvement initiatives?
- How is the collection of these data funded?
- What are the things that work well with using information or data for stroke prevention?
- What are the things that don't work well in terms of information or data for stroke prevention?

Question 6 - What are the governance processes you have around stroke prevention?

Governance processes may include a wide range of components, including ethics, policies, frameworks/procedures, guidelines, risk management, and administration around stroke surveillance.

Prompts

- Who is responsible for the coverage and quality of stroke prevention in your country? e.g., national standards on hospital care, federal or state governments.
- What are the frameworks or guidelines for primary stroke prevention at a local, national or regional level?

- What are the frameworks or guidelines for secondary stroke prevention at a local, national or regional level?
- What types of advisory groups are responsible for monitoring or improving stroke prevention in your country? Do these operate at a national, regional or hospital level?
- What works well with the governance of stroke prevention?
- What isn't working well with the governance of stroke prevention?

Question 7 - Is there something else you would like to say, that we have not talked about in the interview?

Rehabilitation

Question 1 - Can you describe the stroke rehabilitation services in your country?

Prompts

- What activities are provided in terms of stroke rehabilitation in the hospital? e.g., in-patient, outpatient; patient and carer education, home modifications, range of allied health supports – physiotherapy, OT, speech, neuropsychology, fitness.
- What activities are provided in terms of stroke rehabilitation outside of the hospital? e.g., home-based rehabilitation, community rehabilitation, range of allied health supports – physiotherapy, OT, speech, neuropsychology.
- Who delivers these services? Are they provided by the government, non-government or academic sectors?
- What is the scope of these activities? Are they local, regional or national?

Question 2 - Can you describe the workforce for stroke rehabilitation?

Prompts

- What types of settings do people that provide stroke rehabilitation work in?
- What types of training and skills do these people have? e.g., undergraduate/postgraduate, local versus overseas trained, community health workers.
- What types of strategies are there to attract or retain people to contribute work in stroke rehabilitation in your country? e.g., undergraduate or post-graduate training, research fellowships.
- What works well with your workforce for stroke rehabilitation in your country?
- What isn't working well with your workforce for stroke rehabilitation in your country?

Question 3 - How are stroke rehabilitation activities funded in your country?

Prompts

- Can you describe how different levels of government might fund stroke rehabilitation activities? e.g., state or federal.
- What role do non-government organisations play in providing stroke rehabilitation activities? e.g., local stroke associations, community groups.
- How are private organisations involved in funding stroke rehabilitation? e.g., private practices, user pays, private health insurance.
- What do you think about the level of funding that is provided for stroke rehabilitation activities?
- What works well with funding for stroke rehabilitation?

- What isn't working well with funding for stroke rehabilitation?

Question 4 - How is technology used for stroke rehabilitation?

Prompts

- Could include administrative tasks - electronic medical records, patient follow-up and outcome assessments.
- Could include service delivery – telehealth or online systems, use of devices to enhance recovery (robotics).
- What are the barriers to using technology in stroke rehabilitation?
- What facilitates your use of technology for stroke rehabilitation?

Question 5 - What is the role of information or data in your delivery of stroke surveillance?

Prompts

- What are the sources of data to monitor levels of stroke rehabilitation? e.g., hospital-based surveys, clinical quality registries.
- What is the coverage of data on stroke rehabilitation like?
- How are these data used for audit and feedback or quality improvement initiatives?
- How is the collection of these data funded?
- What are the things that work well with using information or data for stroke rehabilitation?
- What are the things that don't work well in terms of information or data for stroke rehabilitation?

Question 6 - What are the governance processes you have around stroke rehabilitation?

Governance processes may include a wide range of components, including ethics, policies, frameworks/procedures, guidelines, risk management, and administration around stroke surveillance.

Prompts

- Who is responsible for the coverage and quality of stroke rehabilitation in your country? e.g., national standards on hospital care, federal or state governments.
- What are the frameworks or guidelines for stroke rehabilitation at a local, national or regional level?
- What types of advisory groups are responsible for monitoring or improving stroke rehabilitation in your country? Do these operate at a national, regional or hospital level?
- What is the role of accreditation of health professionals or hospitals to provide different levels of stroke rehabilitation e? E.g., body that accredits rehabilitation providers.
- What works well with the governance of stroke rehabilitation?
- What isn't working well with the governance of stroke rehabilitation?

Question 7 - Is there something else you would like to say, that we have not talked about in the interview?

Surveillance

Question 1 - Can you describe the stroke surveillance services in your country?

Prompts

- What activities are provided in terms of measuring the burden of stroke? e.g., incidence studies, clinical registries, population risk factor surveys.

- What measures of stroke burden do you have in your country? e.g., incidence, prevalence, survival, patient-reported outcomes?
- What measures of stroke risk factors, such as smoking, blood pressure or weight status, do you have in your country?
- Who delivers these services? Are they provided by the government, non-government or academic sectors?
- What is the scope of these activities? Are they local, regional or national?

Question 2 - Can you describe the workforce for stroke surveillance?

Prompts

- What types of settings do people that provide stroke surveillance work in?
- What types of training and skills do these people have?
- What types of strategies are there to attract or retain people to contribute to stroke surveillance in your country? e.g., undergraduate or post-graduate training, research fellowships.
- What works well with your workforce for stroke surveillance in your country?
- What isn't working well with your workforce for stroke surveillance in your country?

Question 3 - How are stroke surveillance activities funded in your country?

Prompts

- Can you describe how different levels of government might fund surveillance activities?
- What role do non-government organizations play in providing stroke surveillance activities? e.g., WHO, Heart Foundation, Stroke Foundation, ISH.
- How are private organizations or universities funded to provide stroke surveillance services?
- What do you think about the level of funding that is provided for stroke surveillance activities?
- What works well with funding for stroke surveillance?
- What isn't working well with funding for stroke surveillance?

Question 4 - How is technology used for stroke surveillance?

Prompts

- Can you describe how you capture the information on stroke risk factors, incidence or outcomes using technology? Could include electronic medical records, telephones, online surveys, registries.
- What are the barriers to using technology in stroke surveillance?
- What facilitates your use of technology for surveillance?

Question 5 - What is the role of information or data in your delivery of stroke surveillance?

Prompts

- What are the sources of data used for stroke surveillance? e.g., hospital-based surveys, routinely reported data on deaths, data linkage, national risk factor surveys.
- What is the coverage of data like?
- How recent are the data?
- What are the things that work well with using information or data for stroke surveillance?
- What are the things that don't work well in terms of information or data for stroke surveillance?

Question 6 - What are the governance processes you have around stroke surveillance?

Governance processes may include a wide range of components, including ethics, policies, frameworks/procedures, guidelines, risk management, and administration around stroke surveillance.

Prompts

- Who is responsible for health or stroke data?
- What processes are in place around collection and reporting of data on stroke burden or risk factors? e.g., ethics committees?
- What are the frameworks or guidelines for stroke surveillance at a national or regional level?
- Are there terms of reference, policies, procedures, action plans?
- What types of advisory groups are responsible for data relating to surveillance of stroke and its risk factors?
- What works well with the governance of stroke surveillance?
- What isn't working well with the governance of stroke surveillance?

Question 7 - Is there something else you would like to say, that we have not talked about in the interview?

Models of acute stroke care in LMIC

India

Despite the challenges faced by LMICs there are several successful acute stroke care models which have the potential to be scaled up. The physician-based model in Tezpur, India,[25] a hub and spoke model involving government secondary level hospitals[26] has improved the stroke care in these regions including intravenous thrombolysis. Training the community health care workers in rural areas and integrating the stroke patient's referral through primary health care to district hospitals is another successful model implemented in the north-western part of India.[27,28]

China

China's approach to promoting the quality of acute stroke care is very pragmatic and effective via interaction between stroke experts, stroke society and government. In 2010, the first evidence-based national guideline for acute ischaemic stroke were publicized and promoted, which has been updated twice. After the first guideline release, the proportion of intravenous thrombolysis increased steadily. In 2015, stroke centre certification action was initiated by the stroke society and government. Till now, there are 602 comprehensive stroke centres and 1,1178 primary stroke centres in mainland China. Through the formulation and promotion of high-quality guidelines, as well as the certification and improvement plan of stroke centres organized by the government, the quality of acute stroke care in China has been significantly improved, especially for acute stroke reperfusion. For example, the intravenous thrombolysis rate of acute cerebral infarction in China has increased from 1.11% before 2010 to the latest 6.20%, and the median door-to-needle time (DNT) has shortened from 116 minutes before 2010 to the latest 60 minutes.[29-31]

Brazil

Brazil is a good example of how specialists, through the Brazilian Stroke Network, working together with the government, can modify the vision of health authorities and guide them, step-by-step, to develop everything that has been proven to improve the outcome of stroke patients. Since the recognition of stroke care in the country, the elaboration of a national stroke plan (published by the

Ministry of Health (MOH) in 2012), the definition of the structure of the stroke units and team of professionals, implementation of reperfusion treatment, engagement of pre-hospital services with the hospitals in the region, the training of health professionals, the education of the population regarding the warning signs and prevention and the organization of the line of care line for stroke (each component of the stroke care has a role and a protocol, primary care units, pre-hospital, hospital and rehabilitation services).[32,33] Also, MOH has funded research in stroke and used the results to implement treatments and to guide policies as occurred with mechanical thrombectomy evaluated in a Brazilian MOH randomized Clinical Trial in public hospitals.[34] The study showed similar results of 8 previous trials, all performed in high-income countries, and proved that the overwhelming efficacy of MT persists despite the many limitations encountered in the public healthcare system of a developing country. Now, MOH is funding other reperfusion clinical trials and evaluating the polypill for primary stroke prevention. This work over the last 10 years has decreased the stroke mortality in the country by 57.8%.[32,35] Another important initiative includes a public and private partnership for telemedicine in acute stroke care. With a mobile smartphone app, validated to guide thrombolysis,[36] currently 30 public hospitals distributed in the entire country receive real time consultation from 8 stroke experts, increasing access to reperfusion treatments. Also, an app is used to triage the patients with the pre-hospital team connected to the stroke centres, putting the right patient at the right hospital, and decreasing the door-to-reperfusion time.

Supplementary PANEL X: Telemedicine for Stroke from Brazil to Ethiopia

Pilot Phase:

- A pilot programme for telemedicine in stroke in Brazil was implemented in 2008 together with the Ministry of Health in an Emergency Hospital without neurologists in Canoas, a southern city of Brazil covering a population of 323,827 inhabitants. The emergency physician did the first evaluation, called the telestroke team composed of stroke neurologists, who in real time reviewed the neurological examination through a webcam installed in the CT room, and evaluated the CT scan through software installed in the scanner in the hospital, both connected to a laptop. The stroke neurologist helped the doctor in the hospital in the decision of acute treatment including intravenous (IV) thrombolysis. In one year, 56 patients were evaluated and 35 were treated with IV thrombolysis. The median baseline NIHSS score was 10 (IQR 7–13), 57% (20/35) of the patients were independent after 3 months (modified Rankin scale: 0–2), 2.9% (1/35) had symptomatic intracranial haemorrhage, and 5·7% (2/ 35 patients) died. These good results were similar to the international results of IV thrombolysis and were responsible for the approval of telemedicine by the Ministry of Health for stroke in Brazil but without a specific funding for it.[33]

Development of conventional telemedicine:

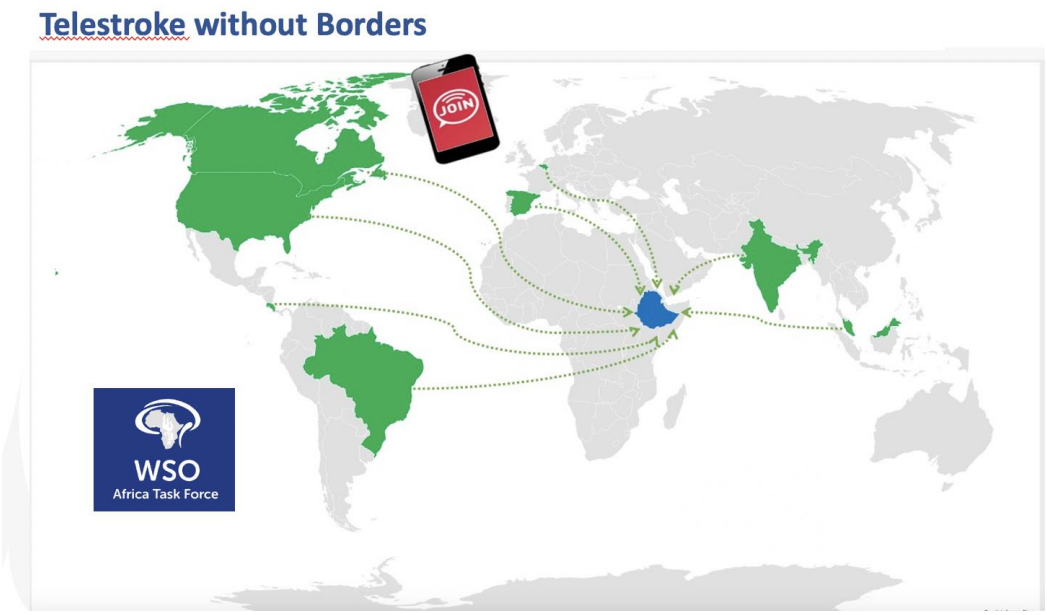
- In 2016 a private hospital in the southern part of Brazil created a programme connected to 6 public Ministry of Health essential stroke centres, none of which had a neurologist. The neurologists on duty in the emergency room (ER) at the private hospital were responsible for advising the telestroke programme. Two of the public hospitals had started to treat stroke patients with IV thrombolysis by emergency physicians before the

telemedicine programme. They treated 14 patients in one year before the telemedicine and 74 in one year after the implementation of the programme showing that the specialist giving support probably increased 5.3-fold the number of treated patients. In two years, the programme was activated for 324 cases in the 6 hospitals and 179 were treated with IV thrombolysis (55%) confirming the same international safety and good outcomes.

- Despite the good results of the pilot project completed in 2009 and international studies showing the benefits of telemedicine, due to a huge lack of stroke centres in several areas of Brazil (due to lack of neurologists to cover all hospitals 24 hours/day, 7 days/week and other reasons), from 2010 to 2019 only 26 hospitals developed telemedicine programmes (20 private participants of a private network of hospitals and 6 public hospitals mentioned before connected to a private hospital).

Migrating to a Mobile Telestroke program:

- The cost of traditional telemedicine continues to limit its more widespread use in LMIC, including in Brazil. Since 2014, Brazil started to use a Health Insurance Portability and Accountability Act compliant, low-cost smartphone application system (JOIN App; Allm, Tokyo, Japan) for the rapid sharing of clinical and neuroimaging patient data to connect the stroke team and to help in the decision-making process in acute stroke care. The validation of this app with 442 acute stroke patients to connect the stroke team in- and outside the hospital aiding in the treatment of acute stroke, including the decision of thrombolytic treatment was published in 2020.[37]
- In 2019 a Brazilian Stroke Network telestroke programme using the Join App, was created with 9 stroke neurologists connected to give support in real time to the new essential public stroke centres without neurologists. The programme is sponsored by the Angels Initiative and Allm Company and in three years already cover 30 hospitals in 9 states. In this period the response time from the neurology team was 2 minutes, there were 2032 cases, 1596 were strokes, 1361 ischemic strokes and 661 thrombolysis. From the patients treated with thrombolytic therapy only 2% had symptomatic intracranial haemorrhage. With this programme it was possible to implement 30 more stroke centres in the country increasing access to thrombolytic therapy. 10 more hospitals are in preparation.
- This experience in Brazil was translated to Ethiopia in a WSO African Task Force initiative to implement acute stroke care in the country. To support this initiative a Telestroke without Borders programme was created using the Join App to connect WSO experts from Canada, the United States, Brazil, Spain, Belgium, Malaysia, India, and Egypt, as volunteers to support in real time the acute stroke care in 3 hospitals in Ethiopia where essential stroke units and thrombolytic medication was implemented for a pilot project. Telemedicine has been working since January 2023 and in two months the first 4 patients were treated with thrombolytics with good results.



Chile

Since 2005, the Chilean MOH has implemented the Explicit Health Guarantees (the AUGE law)[38] which assures access to a CT scan to all stroke patients within less than 24 hours of the event, hospitalization, neurological consultation and access to rehabilitation for all patients with acute strokes. They also include secondary prevention medications (anticoagulant drugs, DOACs, aspirin, clopidogrel, statins and hypotensive medications) as well as coiling or clipping of ruptured aneurysms, as indicated.[39] Reducing stroke case fatality rates was one of the priorities in the National Health Strategy (2011-2020). Specific targets have been established regarding 12-month survival rates, and reducing stroke burden was recently set as the 2020-2030 national health strategy. Also, the Ministry of Health has developed evidence-based national guidelines, the stroke code protocol, and multiple online courses for health professionals to improve treatment opportunities and communication campaigns to increase symptoms recognition in the population. Research about stroke epidemiology and care in the country helped in the decision of the MOH to propose the National Stroke Action in Plan in 2014, which defines prehospital, acute and hospital care as well as ambulatory and rehabilitation care for all patients with stroke. The MOH has also recently published the neurological network management model of care for stroke patients, which includes service provision, organization and structure of the network, support systems and monitoring plan that will serve to support the implementation of the proposed model. The country offers IV thrombolysis in private hospitals and academic medical centres since 1996 (nowadays 34); in public hospitals since 2009 (nowadays 47 public hospitals, and in 15 of them this service is provided using telemedicine), organized stroke care (stroke units) in some hospitals since 2005 and thrombectomy in 8 public (only in centres with at least 50 thrombolysis per year) and 12 private hospitals. The strategies implemented translate into a reduction in the adjusted mortality rate from 47.32 to 33.3 in 2005 and 2015 respectively (per 100,000 people, adjusted by age and sex) largely due to a reduction of case-fatality rate from 33 to 23% at 6 months.

Colombia

Since 2015, the Colombian Network against the Cerebrovascular Attack (RECAVAR) and the Colombian Association of Neurology have been able to influence public policies for stroke by creating national

guidelines for diagnosis and treatment of stroke in adults (2016) and the Regulation of Integral Route of Attention (RIAS) for stroke was created. The development was substantial in the last few years but initially only in private hospitals. Currently, the country has 82 stroke centres, 65 private and 17 public. Thrombectomy is available in 32 private hospitals and only 3 public. The country has few neurologists, and the stroke services are created integrating the emergency physicians. An important experience occurred in Bogotá, the capital of the country with the creation of the Stroke Subred Norte, the first public network for stroke in Colombia. The network started in 2019 with 1 public essential stroke centre - built step by step by only 1 stroke neurologist integrating the emergency physicians and the pre-hospital care Now, the service has 6 neurologists, 2 neurology resident six months a year, 10 beds stroke units connected with 24 minimal stroke services without reperfusion therapy, but trained for basic stroke unit protocols and to transfer the patients through to the ambulance within the time window for thrombolysis. Also, the network is integrated with a private hospital to transfer the candidates for mechanical thrombectomy. The number of patients submitted to reperfusion therapy increased from 2 in 2019, the first year of the project, to 85 at the end of 2021. And from no patients taken to mechanical thrombectomy in the first two years of the experience to more than 50 in the last year since the start of the public-private stroke network with the allied institution. In 2022 the Colombian Alliance for Stroke was founded, working with the MOH to implement more public networks following the same model.

Uruguay

As agreed in the Latin American Stroke Ministerial Meeting in Gramado, Brazil, in 2018,[32] where it was decided to carry forward a strong campaign to reduce the high impact of stroke in Latin America, a specific department responsible for devising a National Stroke Plan was established within the Ministry of Health of Uruguay[40] following the Declaration of Gramado.[41] Scientific associations, universities, scholars, and patient organizations, both at national and international level, took part in devising it. This ends with the generation of the national stroke management guidelines which were accompanied by presidential regulatory decrees and several ordinances that set the foundations of the legal framework for their implementation as of 2020. Forty-two Essential Stroke Centres and 7 Advanced Stroke Centres were strategically established and linked to ensure compliance with international accessibility recommendations, offering, in turn, the required training for their health care teams. A prehospital care protocol was also created for all countrywide mobile units. Stroke was included as a “Care Goal (objective)” for the whole Health System, providing the involved health care organizations with a financial incentive for compliance with the basic objectives related to the treatment of hyperacute stroke. The National Plan started operating during the COVID-19 pandemic and, considering the special circumstances imposed, it made it possible to maintain hyperacute medical care and increase population access to recanalization treatment, particularly mechanical thrombectomy. The reimbursement is paid by the MOH for public and private hospitals after reviewing all performed cases and monitoring the outcomes.

Egypt

The first Stroke Unit in Egypt was founded in 1996 in a public university hospital but the acute stroke treatment with IV thrombolysis started in 2014 in this Stroke Unit. They measured the gaps of pre-hospital and the hospital delays, implemented plans to overcome the problems found, started thrombolysis with donated medications. With the results presented to the MOH, in 2016 thrombolysis was approved in the country. This was the drive to change stroke services in Egypt, with all other Egyptian universities attempting to follow the same path as that of the first SU. In 2020, 95 stroke

units with acute treatment were available in the country.[42] In 2018 thrombectomy was approved and telemedicine was started for remote areas.

Ethiopia

Ethiopia is a low-income country with 118 million inhabitants. Stroke is the first cause of death responsible for 13% of all deaths.[43] The thrombolytic drug is not available in the country and the country had no structure for acute stroke care. In March 2021 Ethiopia asked to the WSO for help to develop acute stroke care. We accepted the challenge to create a model for acute stroke care in a low-income country. The steps were: 1. Creation of an African Task Force with 16 WSO future leaders members and 1 mentor (SM); 2. Define what hospitals would participate – we decided 3 hospitals because we identified champions to run the project in these hospitals; 3. Meeting with neurologists and directors of hospitals to discuss the program; 4. Evaluation of hospitals' structure through WSO Roadmap; 5. Evaluation of hospitals' structure through virtual visits; 6. Request for a grant to support the project (to buy and export thrombolytic medication – Alteplase), to pay a person to collect data, to create and implement a teaching course tailored to the region (supported by the WSO, Angels initiative and Allm Company); 7. Request for a telemedicine App for free, and creation a team of international expert volunteers to give in real time consultation for Ethiopia (telestroke without borders); 8. Creation of an acute stroke unit; 9. Started data collection since October 2021 to have a baseline before the implementation of program, including collecting cost of stroke care; 10. Started education for the population (World Stroke Campaign); 11. Started discussions with Minister of Health to support the program; 12. In person training (hands on, simulation, in August 2022 at the Global Stroke Alliance). The entire team is trained, the data collection started, the stroke units were opened, the alteplase arrived there 1 month ago, the telestroke without borders is ready and waiting for the first patient. Besides thrombolysis, the whole quality of care has already improved with stroke units' protocols.

Global initiatives for acute stroke care

The Angel's Initiative is a non-promotional Health Care initiative of Boehringer Ingelheim, which aims to decrease the inequity of patients' access to high quality stroke care. In partnership with international (i.e., WSO) and national stroke societies, 140 Angels consultants are working with hospitals and health care professionals to create more and better stroke centres, by standardizing processes, implementing best practice and quality monitoring. A global network of 105,000 stroke care specialists from 7,600 hospitals have already joined the Initiative, 75% of them from LMICs. More than 1,300 hospitals have started with stroke treatment and 3,000 have reached Angels Awards for advanced treatment quality.[44-46]

Mission Thrombectomy 2020+ (MT2020+): Mechanical Thrombectomy is a potent therapy for acute large vessel occlusion in stroke that is cost-effective.[47,48] Mission Thrombectomy 2020+ (MT2020+) is a worldwide campaign implemented by a global peer network of stroke and thrombectomy practitioners since 2016 - the Society of Vascular and Intervention Neurology (SVIN) - to accelerate access to thrombectomy using public health interventions.[49] Recent survey data show minimal access to this powerful therapy, with a global median access rate of 2.79% and 0.48% in LMICs. MT2020+ uses global thrombectomy research, policy advocacy tools, stakeholder and public education, strategies to accelerate thrombectomy workforce training, and developing thrombectomy systems of care with an emphasis on resource-limited settings.[50] These activities are implemented through the MT2020+ coordinated network of country-based regional committees. The campaign uses a metric of doubling thrombectomy rates in each region every two years.[50]

Latin American Stroke Ministerial Meeting: The large and increasing burden of stroke in Latin American countries, and the need to meet the United Nations and WHO requirements for reducing the burden of non-communicable disorders brought together stroke experts and representatives of the Ministries of Health of 13 Latin American countries for the 1st Latin American Stroke Ministerial meeting in Gramado, Brazil in August 2018.[125]This meeting discussed the problems and identified ways of cooperating to reduce the burden of stroke in the region. The meeting culminated with the adoption of the Declaration of Gramado,[32] signed by all Ministerial officials and stroke experts. With agreed priorities for stroke prevention, treatment, and research, an opportunity now exists to translate this Declaration into an action plan to reduce the burden of stroke, and since 2018 the countries have followed the Declaration to implement their plans. The commitments and achievements were reviewed in the 2nd meeting in 2020[143] and the 3rd meeting in 2022 showed a huge improvement in the region with governments and specialists working together in the implementation plans. In the 2022 Global Stroke Alliance meeting in Sao Paulo, 17 countries including the Caribbean region and seven Ministers of Health participated in the discussion.

Global Stroke Alliance: The Global Stroke Alliance[51] was created and led by the WSO with the goal of stimulating a global alliance to improve stroke care worldwide and discuss the best strategies for implementing evidence-based interventions at all levels of the care continuum (prevention, treatment, rehabilitation). Bringing together leaders from several countries with experience in implementation, the initiative involves stroke specialists, researchers, health professionals, health managers, scientific societies, public and private hospitals, patient associations, and industry, all working in the same direction: the improvement of stroke care, prevention, and research. The initiative was launched on March 10-13, 2020, in Rio de Janeiro and brought together leaders from 20 countries from different parts of the world with extensive experience in organizing stroke systems of care. The meeting achieved its goal of disseminating knowledge, exchanging experiences, and creating action plans adapted to each region. The dynamics of the event included forums on research, policy, logistics, and education. The 2nd Global Stroke Alliance meeting in São Paulo, August 2022, gathered 1,200 participants from 26 countries to focus on implementation of best practices in stroke care across the care pathway. The meeting drew seven Ministers of Health representing countries across Latin America to build policy commitment to implementation of evidence-based stroke strategies across the region and to support accountability around the commitments made at the first Global Stroke Alliance meeting in 2020. On the first day of the meeting each Minister gave an update regarding the stroke situation in their country and on the progress made since 2020. These strategies showed that in Latin America governments and societies together can reduce the incidence and consequences of stroke, through actions based on scientific evidence that support decisions on healthy public policies and sustainable human development. The commitments will be reviewed in 2023 in Uruguay, invited by the Ministry of Health. Based on the clear success of the Global Stroke Alliance's focus and format for building multi-sectoral engagement in quality stroke care delivery, the WSO will be moving on to expand the approach around the world on a regional basis. The next meeting is scheduled to take place in India in 2023.

WSO Certification of Stroke Centres program: Certification of stroke centres is critical to ensure that hospitals implement and monitor all priority evidence-based strategies that change the natural history of stroke, reducing mortality and disability. It is a great opportunity for continuous improvement of services and qualification of comprehensive assistance in the region, with the commitment of stroke centres as organizers and trainers of the entire local network. The WSO / Ibero-American Stroke Society (SIECV) certification of stroke centres was launched in March 2021 as a priority step to guide national stroke care by evidence- based pathways in the region. The program is based on the WSO Roadmap for Quality of Stroke Services. The certification bases were structured by experienced WSO

and SIECV members working in collaboration with the Society of Vascular and Interventional Neurology / Mission Thrombectomy together with country Medical Societies and Health Managers. Committees were created in 13 Latin American and Caribbean countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Panama, Paraguay, Peru, Mexico, Uruguay, Jamaica, and Dominican Republic) supported by an international team of stroke experts, currently with 80 people working on the implementation of the program. The Certification is free of charge for the hospitals. The step-by-step process for certification includes the following:

- Self-Assessment tool – to facilitate the evaluation of the status of hospitals and the needs for improvement before applying for certification
- Application for certification on the web platform: all mandatory items are considered minimal requirements for classification to each category (hospitals will be classified as Essential and Advanced). Beyond the mandatory requirements, hospitals will need to reach at least 75% of recommended elements to get certification
- If the system confirms the criteria for certification, the hospital should submit several documents to the platform and an onsite visit will be scheduled
- The stroke team should be certified for stroke care, and the quality monitoring through a quality indicators registry is fundamental
- After the onsite visit an international board review will confirm the final certification.

In 18 months, 38 hospitals in 8 countries were certified. Thirty-four are in the process of submitting documents and the whole region is improving the quality of the hospitals interested in receiving certification. The program is planned to be expanded to India in 2022.

RES-Q and SITS-QR: To monitor the quality of acute stroke care is fundamental. A nationwide registry and essential quality control instrument of all patients with stroke admitted to hospitals should be implemented with a minimum dataset.[32] Free international registries are available, such as Registry of Stroke Care Quality – RES-Q, or the Safe Implementations in Treatments in Stroke – SITS-QR and have been used in several countries. There are examples of open-source databases that can be implemented for free by clinicians, allowing for simple set up of a regional or national database if a free-standing platform is preferred. Data dictionaries can be aligned with other international databases to make international benchmarking feasible.[51]

WSO Implementation Task Force: Launched in 2022, the WSO created a strong group of implementation experts from all continents to support professionals and governments in the implementation of stroke prevention, acute care, and rehabilitation. The Task Force will work closely with the *Lancet* Commission Commissioners in implementation the program worldwide. The initiative is based on the following:

- The use of online WSO Roadmap to evaluate the country hospitals situation
- Expert groups to advise on the regional or national plans for implementation of stroke centers working together, which may include the Angels Initiative that will visit the hospitals and coach them to implement the plan locally
- WSO Certification Program to ensure the implementation of all evidence-based strategies in stroke centres with onsite visits
- RES-Q or SITS-QR or national registries to support quality monitoring for the Certification Program
- Expert groups to advise the local plans for a rehabilitation program

- Experts' groups working together with WHO for implementation of the HEARTS Program, with the reorganization of prevention in Primary Care Units across the globe, with the stroke centre as the core of the initiative
- Free online teaching course to support education of all stroke care through World Stroke Academy Platform
- Global Stroke Alliance Meeting rotating through the world to join countries in individual regions discussing the gaps, possible solutions and how to work together.

*American Stroke Association Programs: Get with the Guidelines and Target: Stroke***:** The American Heart Association (AHA) and its American Stroke Association (ASA) division, have run a suite of quality-of-care improvement and stroke centre recognition and certification programs, including "Get With The Guidelines-Stroke (GWTG-S)", Target: Stroke, and, together with The Joint Commission in the US, four tiers of certification of stroke centres, for over two decades. GWTG-Stroke provides hospitals with tools to increase adherence to the evidence-based guidelines.[52] The registry includes more than 5 million stroke patient records, and hospitals can track performance on key quality indicators. These programs have led to measurable improvements in quality of care, including reductions in time to treatment with thrombolysis and endovascular therapy, throughout the US: 84% of eligible patients now receive thrombolytic therapy within 60 minutes of arriving at GWTG-S hospitals and 54% of eligible patients undergo mechanical thrombectomy within 90 minutes of arrival.

The original goals of Target: Stroke Phase 1 (2010-2013) were to ensure that at least 50% of alteplase-treated acute ischaemic stroke patients at participating hospitals were treated within 60 minutes of hospital arrival.[53] Ten key best practice strategies were identified, including (1) hospital pre-notification by Emergency Medical Services; (2) rapid triage protocol and stroke team notification; (3) single call/paging activation system for the entire stroke team; (4) use of a stroke toolkit containing clinical decision support, stroke-specific order sets, guidelines, hospital-specific algorithms, critical pathways, NIH Stroke Scale and other stroke tools; (5) rapid acquisition and interpretation of brain imaging; (6) rapid laboratory testing; (7) pre-mixing medication; (8) rapid access to intravenous alteplase; (9) a team-based approach; and (10) rapid data feedback to the stroke team on each patient's performance data. The second phase of Target: Stroke (2014-2018) was even more aggressive: door-to-needle (DTN) times within 60 minutes for 75% of eligible patients and DTN times within 45 minutes for 50% of eligible patients. Among 154,221 patients receiving thrombolysis within 3 hours of stroke symptom onset at 913 GWTG-Stroke hospitals in the US, median DTN times decreased from 78 minutes before Phase 1 to 50 minutes by the end of Phase 2, and the proportion of patients with DTN≤60 minutes increased from 26% to 69% (P<0.001 for both comparisons).[54] By the end of Phase 2, 75% had achieved 60-minute and 52% 45-minute DTN goals. There were also significant reductions in mortality and haemorrhagic complications, and higher rates of discharge to home. The third phase of Target: Stroke focuses on further improving acute care, including the time for delivery of endovascular therapy.

Based on this success, the AHA/ASA has partnered with international stroke organizations, including the Middle East and North Africa Stroke Organization (MENASO) and the Chinese Stroke Centre Alliance, to bring these approaches to other countries, as well. For example, the ASA is partnering with MENASO to offer primary and secondary stroke centre certification to hospitals in the Middle East and North Africa.

Telemedicine for Stroke from Brazil to Ethiopia

Pilot Phase:

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Barriers and Facilitators of Rehabilitation Services

Recent advances in stroke rehabilitation have not translated to marked improvement in DALYs globally especially in LMIC. Frameworks in implementation science utilize behaviour change as the cornerstone on which evidence-based practices can be actualized.[55] Factors that interact to generate behaviour are grouped as: educational and physical capacity of the individual, the individual's motivation – determined by habits and emotional response, and both physical and social external facilitators as summarized by Michie's COM-B system.[5] Barriers and facilitators of behavioural change can be unravelled by applying these factors to the relevant stroke care stakeholders – patients and carers, healthcare professionals, funders and policymakers, at individual level, community level, and population level.[56] This will facilitate the design of pragmatic solutions.

At the level of the patient and their caregivers, barriers identified include limited capability (awareness, effective education, late presentation),[57] low motivation (safety concerns, cultural bias, poor cooperation), and lack of opportunity due to external factors (road access, inefficient transportation, poor referral process, limited workforce, out-of-pocket payment).[58] Recent systematic review and survey of stroke services corroborated low awareness of rehabilitation services in numerous LMICs.[2,59] In a systematic review of 347 RCT in stroke rehabilitation/intervention in LMICs the financial aspect was also a major barrier.[60] The persistence of out-of-pocket payment in many LMICs implies that stroke survivors are unlikely to fund or pay the care they need. In the advent of home-based rehabilitation, funds to acquire required materials like specialized mattresses, continence aids, medications, and payment for home visits for therapists or nurses are barriers.

Another major barrier is the inadequate number and capability of healthcare providers in low resource settings viz-a-viz clinical competence, multidisciplinary care, and practical skills. This may have resulted from deficient medical curriculum and dysfunctional health systems.[61,62] There are limited organized training and certification/quality assurance programs on relevant rehabilitation techniques e.g., assessment of balance and risk of falls. Low motivational factors, especially in low resource settings, leads to negative provider behaviours with practices like absenteeism, poor communication,

discourteous treatment of patients, all of which leads to distrust by the clientele and reduced service utilization.[57,62]

The negative effects of these actions are particularly marked in low resource setting as the healthcare system there is heavily dependent on individual performance – a healthcare system already stretched from high disease burden and workforce shortages.[62] Systemic and extrinsic factors underlying these challenges – inadequate manpower, poor economy, insecurity, political instability – are also barriers on their own. Many interventions which do not require high technological gadgets and are cost-effective tend to be labour intensive e.g., constraint-induced movement therapy, mirror therapy, and task-oriented training.[60] Therefore, these interventions may not be implementable in LMICs unless the shortage of this category of health-workers is addressed.[57]

Policy makers, funders, and implementation partners in stroke care operate at an organizational level with the goal of addressing ineffective and inefficient rehabilitation structures and processes. This includes provision and distribution of rehabilitation infrastructure, facilities, workforce, supplies, and guidelines – all of which require urgent improvement.[63,64] Worthy of note is the lack of insurance coverage and financing for rehabilitation services in low- and middle-income countries. For example, in the Indian National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke, funding allocation for rehabilitation-related activities in the 85000 million rupees (approximately US$105M) allotted between 2012-2017 for the NPCDCS program is missing.[65,66]

Where clinical practice guidelines exist, emphasis was not placed on pragmatism and adaptable solutions.[16] Knowledge translation is not realistic where structures for successful implementation are not available. There is a need to focus on adapting clinical evidence to local context to ensure actionable recommendations. An example of such a project is the Global Consortium on Stroke rehabilitation currently evaluating the available LMIC clinical practice guidelines against AGREE-II and AGREE-REX criteria followed by WSO guidelines. The cost of staff and equipment required – intermittent pneumatic compression devices, functional electrical stimulator, gymnasium – are unaffordable by a number of hospitals unlikely to invest in such projects due to fear of being unprofitable. Keeping up with current rehabilitation trends and participating in the investigation of experimental interventions such as robotic rehabilitation and brain computer interfaces may be difficult in LMICs as funds for setting up such facilities are astronomical.[60,67] Thus, over 90% of randomized control post-stroke rehabilitation trials are done in HICs.[60]

Other system-level barriers preventing efficient use of the limited available resources include lack of clear care pathways, nonavailability of clinical prediction tools, dysfunctional referral systems, suboptimal information systems, absent task-shifting protocols, and inter-disciplinary disharmony in hospitals. On a larger scale, policy makers must address the poor economy, insecurity, and corruption which foster negative behaviour. Policy makers and implementation partners in an holistic ecosystem should co-create and rework funding, clinical governance and rehabilitation systems for in-hospital, community, and home-based, rehabilitation.[68]

Special Interest Group Clinical Pathways (SIG CP) of the WFNR organized an international survey

The World Federation of Neurorehabilitation (WFNR) issued over 150 specific evidence-based stroke rehabilitation practice recommendations in 2021, developed by 14 multi-professional international author groups.[69] From June to August 2022 the Special Interest Group Clinical Pathways (SIG CP) of

the WFNR organized an international survey asking healthcare professionals (HCPs) involved in neurorehabilitation to indicate to what degree these practice recommendations can be implemented in their region (not necessarily in their institution or by themselves), and, if they could not be implemented as indicated, to provide information about the reasons why. Pre-defined categories of implementation barriers were shortage of HCPs, time, devices, lack of knowledge/skills among HCPs, lack of cost coverage, or that the service was not considered important for the region.

All members of the WFNR and previous attendees of the WFNR certificate teaching course on evidence-based stroke rehabilitation (held from January to May 2021) were personally invited to participate by e-Mail (May / June 2022) with a reminder sent after several weeks. A total of 66 participated in the survey and commented on at least the first recommendation of the survey. Supplementary Table 7 provides information about the participants, and the subgroups coming from High Income Countries (HICs) (29% of participants) or Low- and Middle-Income Countries (LMICs) (71% of participants), resp.

The respondents collectively covered a geographical distribution: 22 respondents (33%) came from the East Asia & Pacific region, 14 (21 %) from Europe & Central Asia, 10 (15%) from Latin America & Caribbean, 6 (9%) from Middle East & North Africa, 4 (6%) from South Asia, and 10 (15%) from Sub-Saharan Africa. Respondents were multi-professional (mainly medical doctors and physiotherapists) with a broad spectrum of age distribution, highest degree obtained, and years of professional experience with many having long-standing experience in clinical neurorehabilitation. Overall, the type of service included the "continuum of care" of healthcare services, i.e., from acute care to outpatient treatment. Comparing the subgroups coming from HICs or LIMCs indicated for the LIMCs a higher percentage of female responders, a higher percentage with a Bachelor's degree and a lower percentage holding a Ph.D. Working in an early rehabilitation setting was less frequently the institutional background for respondents from LMICs compared to those from HIC; the reverse was true for working in a multidisciplinary outpatient service. While these differences were statistically significant, the overall characteristics of the two subgroups of HCPs were largely comparable.

It was then of interest to note to what degree the WFNR practice recommendations could be implemented, and whether that differed between HICs and LMICs. A first set of 7 recommendations addressing goal setting with the ICF (International Classification of Functioning, Disability and Health) and the multidisciplinary team approach in stroke rehabilitation was consistently commented on by survey participants. These results are reported here.

Specifically, the seven recommendations addressed the issues of the multidisciplinary team approach in stroke rehabilitation were (recommendation, REC 1), the early initiation of stroke rehabilitation on stroke units (REC 2) and its continuation after discharge (REC 3), the integration of HCPs involved and the co-ordination of their activities (REC 4), the evaluation of structure and processes of team work (REC 5), the use of the ICF for goal setting (REC 6), as well as goal syntax, patient's perceptions of goal importance and self-efficacy (REC 7).[70]

Overall, implementation rates of about 60 to 80% (response categories *as indicated* or *regularly, but less than indicated*) were documented while in 20 to 40% of regional service situations implementation rates were insufficient (response categories *much less than indicated* or *cannot be applied*). This pattern was largely comparable between HICs and LMICs for most recommendations.

There were also however, significant differences between HICs and LMICs (Supplementary Table 8). The multidisciplinary team approach in stroke rehabilitation (REC 1) seemed to be a prevailing standard in HICs (95% of responses fell in the categories *as indicated* or *regularly, but less than indicated*) while the diversity of implementation was bigger in LMICs with 1/3 of situations without these pivotal aspects of stroke care (34% of responses in the category *much less than indicated*). A similar disparity between HICs and LMICs was observed for the implementation (or lack) of continuation of stroke rehabilitation after discharge (REC 3; only 6% of HIC respondents, but 26% of LMIC respondents rated *much less than indicated*).

Because of these inter-group differences, the frequency of potential barriers was compared between HICs and LMICs for REC1 and REC3.

The analyses for REC 1 indicated that a shortage of HCPs for the service was more frequently identified as barrier for the implementation of a *multidisciplinary team approach* in stroke rehabilitation among respondents from LMICs (REC 1, mean [95% confidence interval, CI] for *shortage of HCPs for the service* [range 0 – 1.0]: LMIC 0.64 [95% 0.50 – 0.78] (n=47), HIC 0.32 [95% 0.09 – 0.55] (n=19), *P*=0.0169 (t test)). For REC 1, a *shortage of devices* was also noted by some LMIC respondents (LMIC 0.11 [95% 0.01 – 0.20] (n=47), HIC 0 [95% 0 – 0]] (n=19), *P*=0.0237 (t test, unequal variance).

For REC 3, *continuation of rehabilitation after discharge*, a *lack of knowledge/skills among healthcare professionals to provide the service* was more frequently indicated by participants from HICs (LMIC 0.21 [95% 0.09 – 0.33] (n=47), HIC 0.53 [95% 0.28 – 0.77] (n=19), *P*=0.0116 (t test)). While this might seem contra-intuitive, the observation can be explained by the fact that in a situation where continuation of rehabilitation is implemented, the lack of specific knowledge for stroke rehabilitation among HCPs in the community setting might more frequently become an issue.

In summary, while the survey was limited as to the total number of respondents it was at the same time representative regarding the global distribution of participants, being multi-professional, frequently well experienced in neurorehabilitation, and working in different settings from acute care to outpatient rehabilitation. The lack of fundamental aspects of the team approach for stroke rehabilitation in 20 to 40% of healthcare settings globally raises concerns and points to a need to address such service deficiencies with a world-wide perspective. Given the ample evidence that the multidisciplinary team approach is a key factor in reducing stroke-related disability helping to prevent the need for institutionalisation after stroke makes this a topic of high priority.[57] In addition, the data indicates disparities between HICs and LMICs that help to focus on deficiencies at a regional level. This applies both to the establishment of interdisciplinary teams with specific training and experience in the field and the continuation of stroke rehabilitation after discharge in LMICs. Accordingly, there is a substantial need for capacity building in LMICs. And there is the question of HCPs' knowledge and skills for a multidisciplinary team approach in the community in HICs that needs to be addressed.

Gaps in Stroke Rehabilitation Evidence-base

Overall, substantial evidence from clinical research including RCTs and systematic reviews with meta-analyses of RCTs is available to guide clinical decision making in certain areas of post-stroke rehabilitation.[69,71] Cochrane review evidence clearly indicates that stroke patients who receive organized multi-disciplinary inpatient (stroke unit) care with a team approach are more likely to be

alive, independent, and living at home one year after the stroke.[72] These apparent benefits were independent of age, sex, initial stroke severity, or stroke type, and were most obvious in units based in a discrete stroke ward.

Besides the overall benefit of coordinated stroke rehabilitation care there is substantiated evidence that certain rehabilitation interventions generate specific clinically relevant benefits for stroke survivors, examples being constrained-induced movement therapy to overcome the learnt non-use of the affected arm, arm robot therapy to improve function with more severely paretic arms,[73] electromechanical gait training to help regain the ability to walk independently,[74] or treadmill training with partial body weight support walking speed and endurance[75] to name just a few. It seems that the evidence-based motor rehabilitation has reached a status that can well inform clinical decision making, especially for the subacute phase (1-6 months post stroke)[76] and for High Income Country settings.

Systematic efforts are, however, rarely realized while too many small under-powered, low quality, single-centre clinical trials try to seek information more or less based on certain scientific grounds and having a minimal chance to be informative and authoritative. More collaborative and systematic research initiatives with neuroscientists, clinicians, and clinical epidemiologist populating the scene would be warranted to address the above-mentioned core gaps of stroke rehabilitation evidence in a systematic manner.

In addition, in order to generate such "universally applicable" primary evidence from clinical trials solidly grounded in neurorehabilitation, there is equally and consequently a high demand for healthcare research addressing how the evidence generated can best be contextualized and applied in various healthcare situations world-wide where considerable difference existed between the Low- and the High-Income Countries.

With increasingly high cost associated with clinical trials, certain clinical trials should be encouraged to be conducted in Low-Income Countries to generate applicable evidence to the specific populations in certain countries and regions. This requires more collaborative global efforts with certain global funding mechanisms in place in order to make it feasible, implementable, and executable. The logic would be that while the collaborative brain-oriented research (from basic science to clinical trials) would inform clinical decision making on "what" to do to best to reduce stroke-related disability, a second stream of geographically collaborative research would be necessary to test and prove "how" such knowledge could best be adapted to cultural and healthcare situations and implemented in different regions of the world to generate the best possible benefit for stroke survivors e.g., the Global Consortium on Stroke.

Gap Analysis of Stroke Rehabilitation Services and Settings

Due to limited health resources, factors with the highest prevalence and largest effect should be identified based on the complexity theory[77-79] and addressed. Among the rehabilitation services recommended, expansion beyond physiotherapy services and improved access pose major challenges. Rehabilitation for stroke patients is generally less accessible compared with acute stroke care.[80] This is corroborated by a systematic review which reported generally low access to rehabilitation service in LMICs due to lack of awareness, logistics, affordability, and poor client-

provider interactions.[59] To expand rehabilitation services in low resource setting, task-shifting and task-sharing with trained caregivers and other non-specialist healthcare providers e.g., community health extension workers have been recommended. Nurse-led stroke aftercare addressing psychosocial functioning showed to be a low-cost intervention and is likely to be a cost-effective addition to care-as-usual. It plays an important role by screening and addressing psychosocial problems not covered by usual care.[81]

Another major gap is the lack of education of patients. This is a low-cost important intervention which can leverage the availability of smartphones and social media, through telemedicine/tele-education using training videos in various languages to support rehabilitation. This will need to be facilitated by affordable internet services, computer or mobile devices and quality assurance/ certification processes as well as care pathways and supervision. Also, if telehealth is to become a common mode of service delivery, health professionals need training in order to achieve successful implementation. Without this training, it is not surprising that therapists prefer in-person models of delivery to telehealth. Such training needs to go beyond technical expertise in operating telehealth platforms and navigating privacy, legislative requirements, and billing systems.[82]

Affordability is a major gap, particularly in LMIC. Promoting policies and health financing to improve rehabilitation services are crucial in the long term. Financing solutions should cover patient payment options for services (including health insurance), subsidized drugs and other interventions, health-provider renumeration, training and deployment, provision and maintenance of infrastructure, and administrative services. Also needed are development and promotion of relatively low-cost interventions, such as smartphone apps for fitness, exercise routines, language practice, and so on. Some interventions that augment behavioural therapy, such as transcranial direct current stimulation (tDCS), are also very low cost (e.g., about $100 for a tDCS device), but clinicians need to be trained to use them. Considering inter-regional and intra-regional variation in stroke experience, and barriers and facilitators to stroke rehabilitation, multi-level health policy, fiscal solution, advocacy, and service delivery reforms are needed.[80] Therefore, there is a need for sensitization of all stakeholders within the WSO-*Lancet Neurology* Stroke Task Force (including policymakers, patients, caregivers, funders, implementation partners and healthcare providers) on the need, provision of and care pathways for rehabilitation services for stroke patients.

Outcome assessment is a critical component of rehabilitation services. Notably, there is a lack of consensus on the core set of outcome assessment tools. The wide variation in rehabilitation construct (e.g., motor function, muscle strength, cognition, perception, depression, at a body function level, ADL, and mobility scales at the activity level etc., as well as quality of life and participation) and their utility could lead to a lack of direction and focus during assessment, especially in LMIC where specialists are scant. While several outcome measures require specialized equipment for objective assessment, many questionnaire-based tools have been validated for use in HIC. However, they are not yet validated or readily used in LMIC.[60]

Pragmatic Recommendations from Guidelines

A number of surveys have identified priorities and recommendations to enhance uptake of evidence-based stroke rehabilitation.[83,84] Results have shown socioeconomic and intra-country variations in priorities for and feasibility of practice change in stroke rehabilitation.[84] Improving interdisciplinary

care and access to health services globally are initiatives with global ramifications while development of relevant clinical practice guidelines remain a priority for low-resource settings.[3,84] Further studies should be conducted using the criteria and processes described here to identify local priorities both in stroke rehabilitation and implementation of research in their clinical areas. This will ensure efficient use of limited resources. It is important to harness resources to facilitate implementation, including toolkits to audit and facilitate interdisciplinary care, address consumer fatigue, and mitigate social isolation.[83]

In the interim, enhancing self-efficacy, supervised task-sharing with available personnel and *capable supported* family members *may* bridge the gap and help to deliver the required frequency and intensity of impairment- and task-oriented practice to facilitate neuroplasticity and recovery.[85,86] A few studies have shown the effectiveness of supervised home-based self-rehabilitation programs for improving upper-limb function.[87] The RECOVER trial showed nurse-led, digital supported, caregiver-delivered stroke rehabilitation programs did not improve patient physical functioning after stroke.[88] However, the results of the ATTEND trial raises some doubts on how far this can go.[89,90] But, task-shifting with continued supervision by rehabilitation professionals over prolonged periods of time should be studied. Therefore, randomized controlled trials are still required to investigate the effectiveness of task-sharing with a combination of outpatient rehabilitation supplemented by supervised family-based care for suitable patients. Future research should perhaps also investigate caregiver-mediated interventions combined with e-health and telerehabilitation services to augment training and allow adequate feedback.[91]

Indeed, rehabilitation can be offered in various settings including intensive care, inpatient care, outpatient care, community-based and family-based care. The Locomotor Experience Applied Post-Stroke (LEAPS) trial reported that home-based rehabilitation resulted in improvement in functional walking with the protocol used in the trial found to be more effective than the instrument-based intervention in institutionalized health rehabilitation centres, which are more expensive and not practical. In Nigeria, a few community-based interventions have yielded success at the primary healthcare level with reduction in disability.[92,93] Also, the caregiver-mediated intervention randomized controlled trial conducted in Taiwan showed improved functional outcome with family-assisted care under the supervision of a specialist.[94,95]

The gap in education on patient management and self-management could be targeted across all countries to improve management of stroke patients by developing educational tools (including videos and apps) that can be disseminated globally. Tele-rehabilitation could also provide support as in many LICs, distance is the main cause for not accessing proper rehabilitation services. The results from the recent trial prove that video conferencing systems to connect specialist in urban areas to healthcare specialist in the rural areas is feasible in LMICs.[96] This can also assist with task-sharing and task-shifting needed to cope with the strain on shortage of human resources in the health sector. This in combination with phone apps for monitoring can go a long way in LMIC communities whose residents have access to mobile phone.

To minimize cost and prolong life, it is critical to prevent complications such as pressure ulcers, aspiration, deep venous thrombosis, urinary tract infections and recurrent stroke. To achieve this, materials such as waterbeds, orthotics, wheelchair, Paul's tubing/urethral catheter, intermittent compressive pneumatic devices, and medications including anti-hypertensive, antidepressants, anti-

spasticity medications and heparin are required. Financing solutions including local manufacturing, health insurance systems and subsidies can improve access to these materials.

Meanwhile, better organization and optimization of available resources through care protocols is essential[3] globally, including in some HIC which lack standardized follow up care.[97] Standard protocols should include multiple assessments of functional impairment, fluid balance and nutrition, cognition, communication, mood disorders, and rehabilitation goals.[98,99] Most of the existing guidelines emanate from HIC. In the absence of alternatives, there is a need to adapt and implement them in LMIC settings until local evidence emerges. While they might be valid in terms of the evidence provided, they are purpose-made for HIC, and their recommendations reflect a combination of both evidence and HIC-based health-care systems. A major facilitator to overcome this barrier for implementation in LMIC is the regional adaptation of practice recommendations by making use of the evidence,[60] but actively transforming recommendations regionally into clinical pathways that reflect the local health care priorities, settings and capacities.[71] The 'Key recommendations to improve stroke rehabilitation services worldwide' presented in the tables below provide the means to do so.

METHODOLOGY OF GLOBAL STROKE ECONOMIC BURDEN ESTIMATES FOR 2050

Step 1: Estimating Incidence and Deaths by Type of Stroke, by Country

Feigin et. al. (2022) projected deaths and DALYs lost from stroke in 2050 globally (section 1 of the manuscript), by geographic region, and for populations aged over and under 60 years of age. However, the generation of the projected economic consequences of stroke (direct costs and income losses) required additional information at the country-level on incidence and deaths, given income losses typically rely on estimates of GDP per worker, and GDP per capita (for each country). Moreover, for most analytical purposes, methodologies for generation of income losses define 15-64 years as the working age group. Because we did not have access to the model parameters used to generate stroke incidence and deaths, we relied upon an alternative estimation procedure to estimate stroke incidence and deaths, and then calibrated our projections exactly equal to the projections of stroke deaths at the World Bank (income) region level used in our paper. The methodology used is set out below.

- Estimate separate cross-country models that regress DALYs lost from stroke, and stroke deaths in 2019 (by stroke type), on population size, the share of population aged 65 years and over, and regional dummies, with China and India treated separately – using Global Burden of Disease (GBD) data and information from the World Bank Development Indicators database, for 2019. The overall regression fit was good for all equations, with the coefficient of determination ranging from 0.91 to 0.97, depending on stroke type.
- DALYs lost and stroke deaths for 2050 were projected using the coefficients from the regression models outlined above, along with additional data on population projections for 2050 from UN population statistics by country, as well as the share of population over 65 years.
- Country-level projections for DALYs lost from stroke and stroke deaths were summed up over specific regions for which analogous data were available on stroke deaths and DALYs lost from stroke (by type of stroke).

- Projections of region-specific stroke deaths and DALYs lost from stroke were compared with analogous projections for 2019.[19] Our estimates were somewhat higher for High-Income Countries and for the South Asian region, potentially reflecting adjustments in mortality and improved stroke outcomes in these regions over time, that may have been better captured in Feigin et. al.[19] Therefore, country-specific 2050 projections were adjusted so that the total for DALYs lost from stroke and stroke deaths across countries within a region for 2050 exactly equalled the projected region totals reported in Feigen et. al.[19]
- Next, equations for incidence of stroke (by type) were estimated, with DALYs lost and deaths for that stroke type, along with region dummies as explanatory variables, using GBD data for 2019. The fit was again quite good, with the coefficient of determination ranging from 0.85 to 0.99. The coefficient estimates obtained were used to translate projected estimates for DALYs lost from stroke and projected stroke deaths for 2050 (after adjustment – see above) into projected incidence (by stroke type) in 2050 for each country.
- The number of incident cases of stroke who were aged between 15-64 years in each country was estimated using an age-specific variant of the model used to project incident cases for all ages (above). Because the projection required DALY estimates for 2050 and stroke deaths for 2050 for the age group 15-64 years, and Feigin et. al.[19] reported estimates only for 15-59 years and 60+ years (for DALYs lost from stroke and stroke deaths), the latter set of estimates was adjusted to capture estimates for 15-64 years. Specifically, the share of population aged 15-64 years in total stroke deaths was estimated by *adjusting upwards* the share of people 15-59 years old in stroke deaths (as in Feigin et. al.)[19] by the ratio of population aged 15-64 years to the ratio of population aged 15-60 years (using population projection data from the United Nations Population Statistics), and similarly, for DALYs lost from stroke.

Step 2: Economic Data

- The projected annual economic burden of stroke was defined as the costs of acute care and treatment and rehabilitation following stroke *plus* income losses among incident stroke cases as outlined in the supplement.
- Projected unit costs of acute care and treatment and rehabilitation for 2050 for World Bank economic regions (and separately for China and India) were measured in 2017 US$ and derived from estimates reported in Table 3 of the supplementary in Owolabi et. al.,[1] following conversion of purchasing power parity estimates into US$ at 2017 prices. Two scenarios were considered for projecting the costs of treatment and rehabilitation. Under the first scenario, it was assumed that unit costs of acute care and follow-up treatment and rehabilitation rose at an annual rate that was 3% points above the non-medical inflation rate. In the second scenario, it was assumed that unit costs of acute care and follow-up treatment and rehabilitation rose at an annual rate that was 1% point above the non-medical inflation rate.
- The annual average rate of growth of real GDP per capita between 2020 and 2050 was estimated as follows. A simplified version of an empirical growth equation was estimated using cross-sectional data, with annual average rate of growth of GDP per capita (in 2015 US$) during 1990-2020 as the dependent variable, and the log of baseline GDP per capita (i.e., GDP per capita in 1990 (in 2015 US$)) (to capture "conditional convergence"), regional dummies, and rate of change of the share of population aged 15-64 years (to capture labour supply and demographic dividend effects) as the explanatory variables.[100] Then the annual average rate of growth of real GDP per capita for each country during 2020-2050 was projected using the

coefficients of the growth equation, a baseline value of the log of GDP per capita for 2020 (in 2015US$), and the estimated annual average rate of growth of the share of population aged 15-64 years between 2020 and 2050 (using UN population statistics data). China was an outlier in the estimates with a projected annual average rate of growth (8.6%) that was much larger than for other countries and appeared unrealistic given its rapidly changing demographic scenario. China's projected growth rate was therefore adjusted downwards to reflect two scenarios: (a) an annual average rate of growth of real GDP per capita equal to the country with the second fastest projected growth – of 3.9% annually; and (b) an annual average rate of growth of real GDP per capita equivalent to that of High-Income Countries whose ranks China is expected to join prior to 2050 (1.2% per year).

The estimated annual average rate of growth of real GDP per capita during 2020-50, along with information on GDP per capita in 2020 (2015 US$), was used to project real GDP per capita for each country in 2050 (in 2015 US$). Information on the GDP deflator for the US for 2017 was then used to convert projected GDP per capita for 2050 (in US$ 2015) to GDP per capita in US$ 2017 terms.

Simultaneously, GDP per person aged 15-64 years for 2050 (in US$ 2017) for each country was estimated by multiplying (projected) GDP per capita in 2050 (in US$ 2017) with (1/share of population aged 15-64 years).

- It was assumed that the average age at which stroke occurred for people aged 15-64 years in 2050 was the same as in 2020. It was also assumed that the expected life span of people aged 15-64 years in 2050 with stroke was the same as in 2017. Because of the relationship between prevalence, incidence, and life expectancy at the time of stroke, this assumption is potentially problematic. Because stroke mortality can be expected to decline over time (to 2050), one may expect income losses and treatment expenses to be lower than estimated here.

Step 3: Translating data on costs of treatment and rehabilitation and expected GDP per worker into estimates of direct costs and income losses from incident stroke cases.

- The methods used to project 2050 economic costs are exactly the same as reported in the supplementary appendix to Owolabi et. al. 2022.[1]
- Income losses were considered for two scenarios – one where China's GDP per capita grows at a 3.9% per year and one where it grows at 1.2% per year.
- Treatment and rehabilitation expenditures were considered under two scenarios: one where the annual rate of growth of the unit costs of acute care and follow-up treatment and rehabilitation exceeded the annual average rate of non-medical inflation by 1%, and one where they exceeded the annual average rate of growth of non-medical inflation by 3%.

Evidence supporting the use of the Stroke Riskometer app for stroke prevention

1. Feasibility and efficacy: A pilot RCT in NZ[101,102] showed significant motivational value of the use of relative risk estimates for communicating stroke risk to users, high acceptability (84%), and potential efficacy of the lifestyle modification and improved awareness of stroke in the App Group (13%). There was decreased awareness of stroke by 8% in the Control Group, and an overall increase in the Life Simple's 7 score by 0.36 points (95% CI -2.10 to 1.38) from baseline to six months in the App group compared to almost no change in the LS7 in the Control group (0.01 [95% CI -1.34 to 1.32]), which equates to a projected 3% reduction in stroke incidence. Statistically significant improvement in stroke awareness (as measured by the validated Malay version of the ABCD-M questionnaire)[103] in the Stroke Riskometer app group compared to the usual care group was shown in a single-blinded RCT (n=116) in Malaysia[104] (efficacy paper is in preparation). Full-scale RCTs on the Stroke Riskometer app for stroke prevention are currently underway in Australia/NZ (PERKS International trial ID ACTRN12621000211864), and Brazil.[105]
2. Evidence from qualitative studies: A qualitative exploration demonstrated that Stroke Riskometer users acknowledge their relative risk of a stroke, the physical and socio-economic implications of a stroke and the importance of healthy lifestyle changes.[106] Our data suggest that long-term use of the Stroke Riskometer may be better facilitated when used in combination with other ongoing measures and interventions (e.g. having a peer support system from nurse educators or community health workers).
3. Validation: The Stroke Riskometer app has been validated in three populations (The Netherlands, Russia and NZ) against Framingham Stroke Risk Score and QStroke.[107] It was also cross-culturally validated in 13 countries (Australia, Brazil. France, India, Italy, Kazakhstan, Malaysia, NZ, Nigeria, Russia, Ukraine, UK, and USA).[108]
4. Endorsements: The Stroke Riskometer app is endorsed by the World Stroke Organization, World Federation of Neurology, World Heart Federation, European Stroke Organisation, and by a number of national stroke organisations (Australia, France, China etc.), and recommended for global use by the World Stroke Organization,[109,110] American Stroke Association and NCD Alliance.[111] In 2022, the app was awarded the WHO Western Pacific Innovation Challenge Prize.[112]
5. Global usage: currently used in 78 countries, this free to use app is already translated into 19 languages and available to over 5.3 billion people in their native languages.[1] A Google Scholar search list of articles that has mentioned the Stroke Riskometer app yielded 244 peer-reviewed publications, as shown below.

Google Scholar search list of articles that has mentioned "Stroke Riskometer app" (in alphabetic order by first author name)

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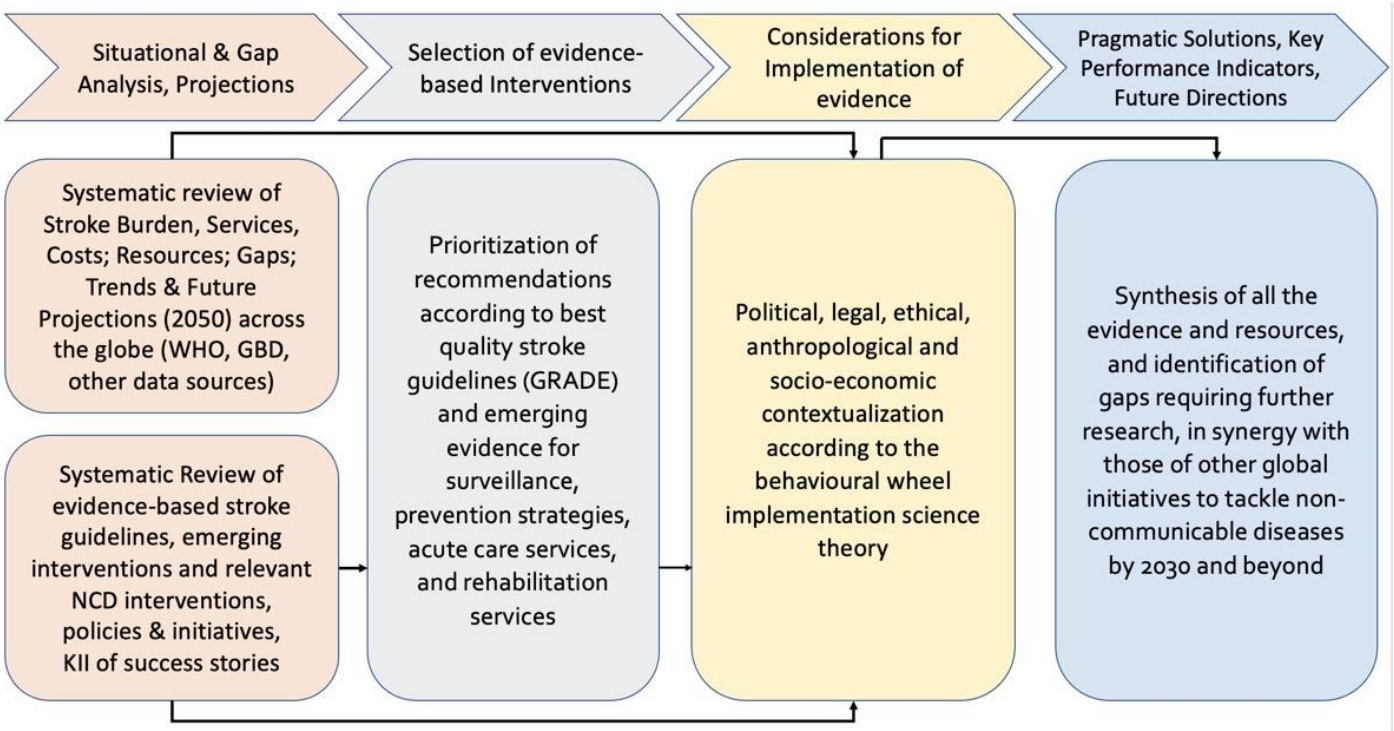
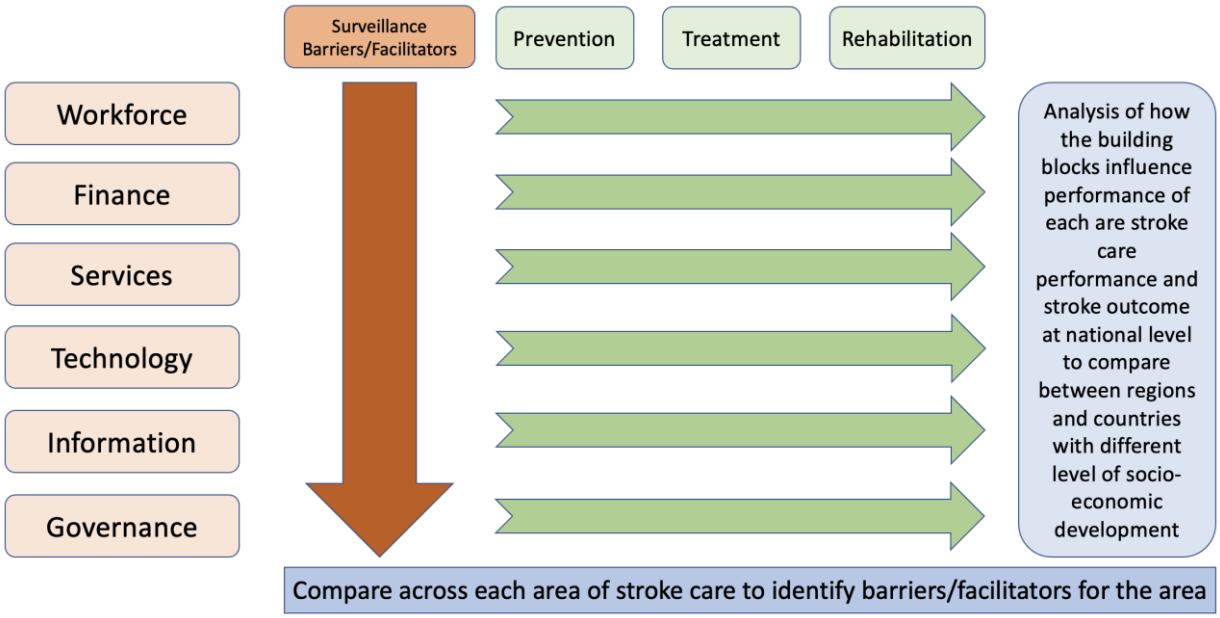
SUPPLEMENTARY FIGURES

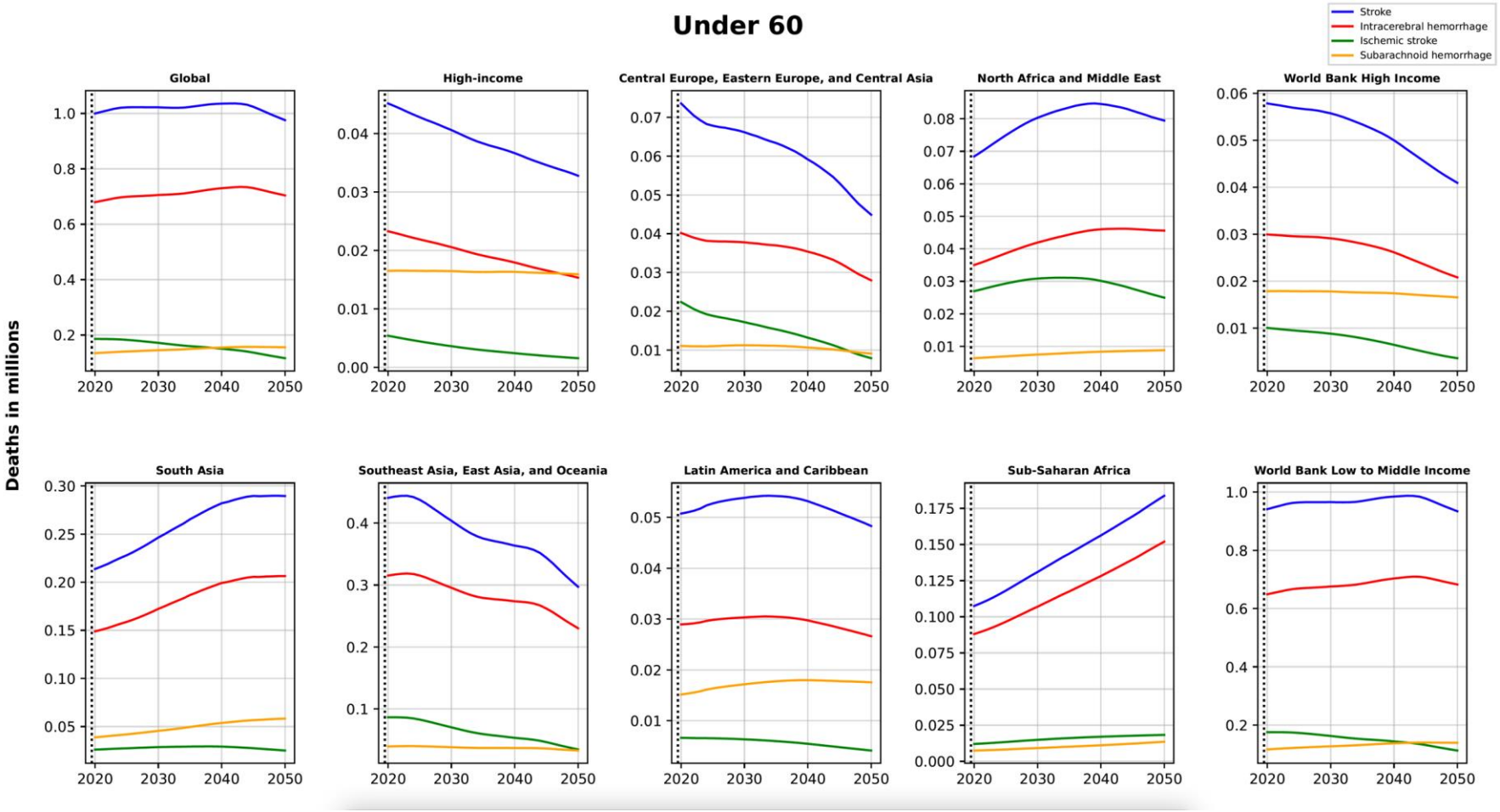
Supplementary Figure 1: Methodological workflow for deriving pragmatic solutions to reduce the global burden of stroke

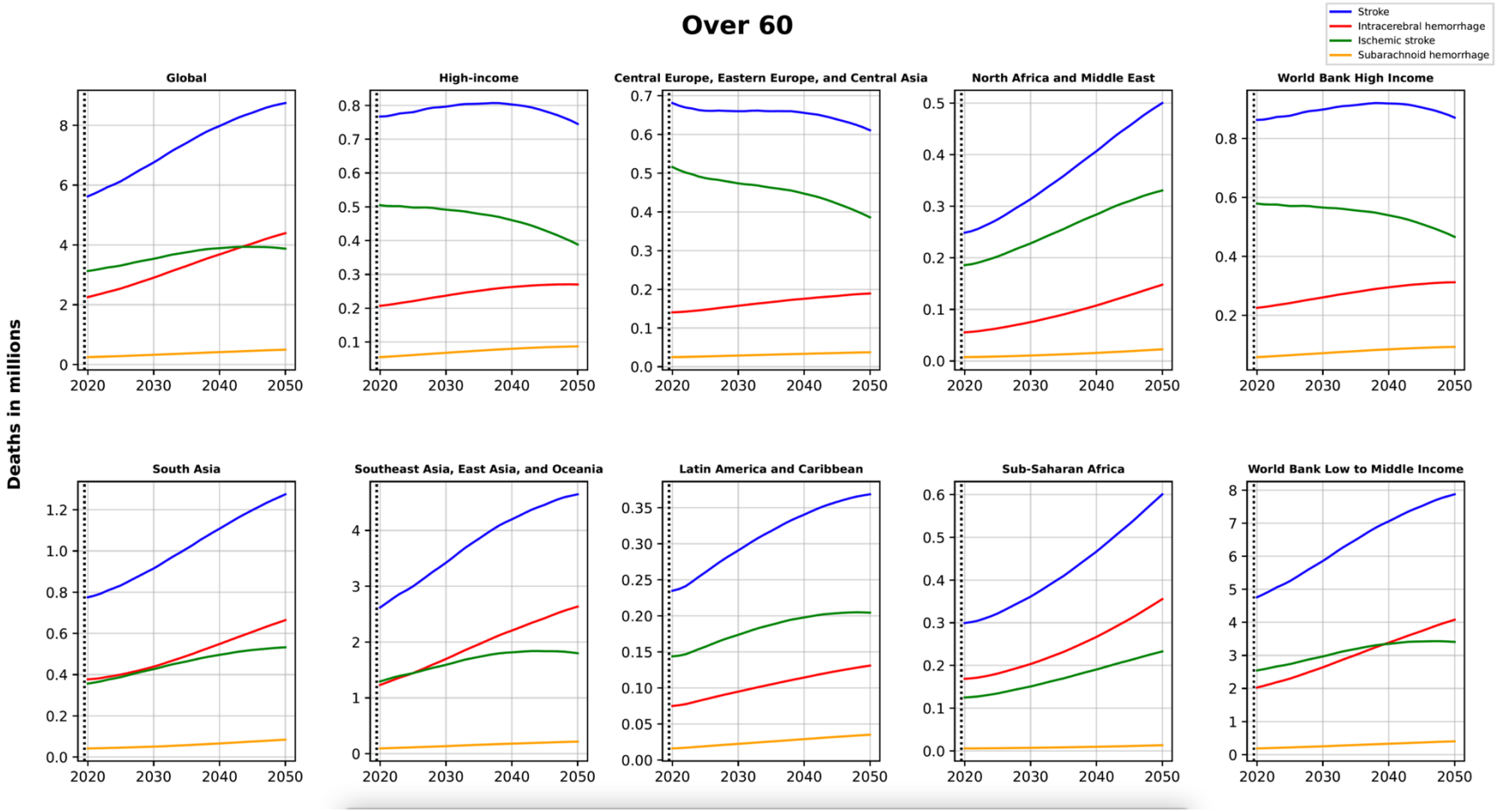


Supplementary Figure 2. Matrix for multiple case study mixed methods analysis of stroke services

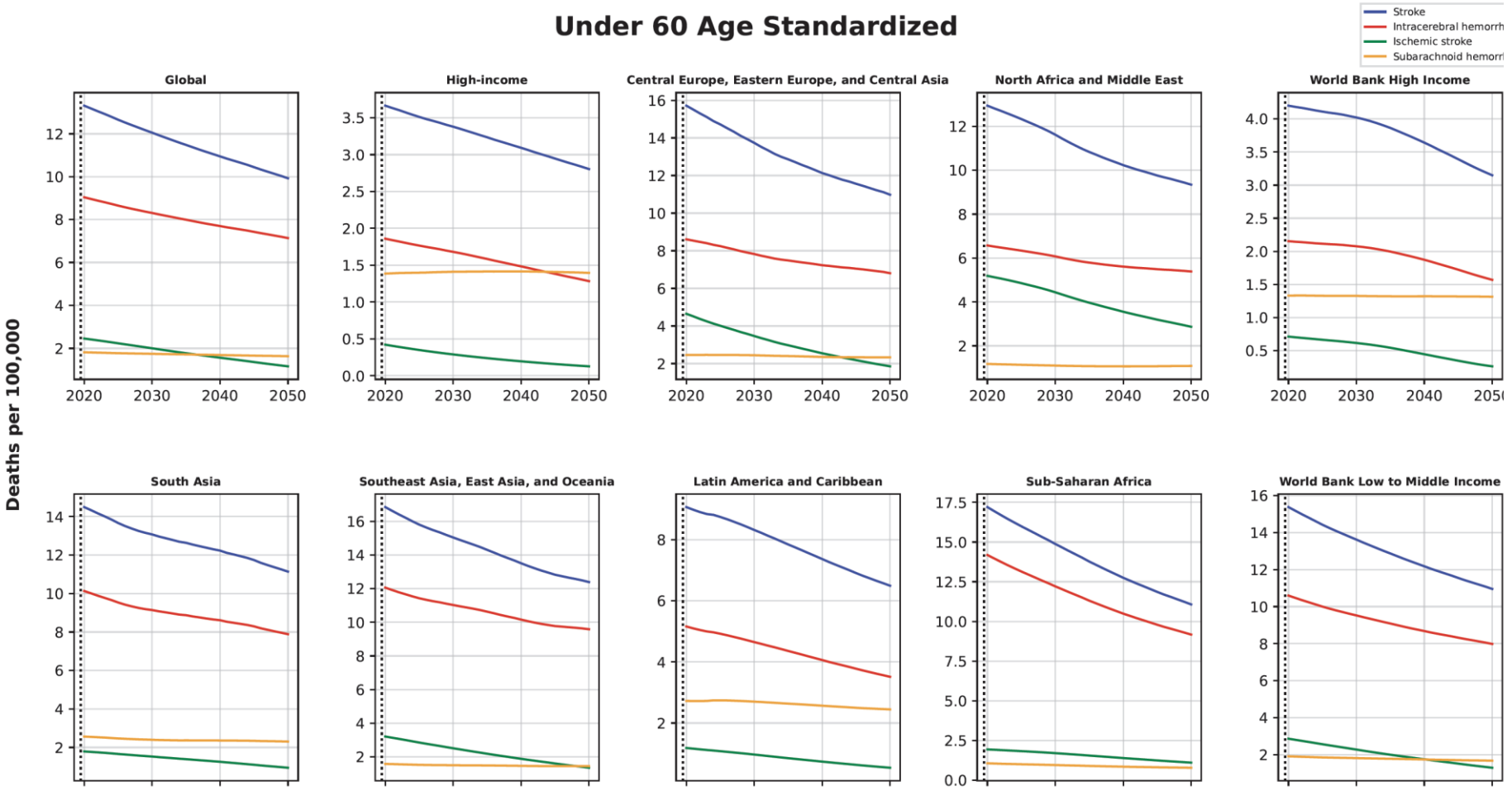


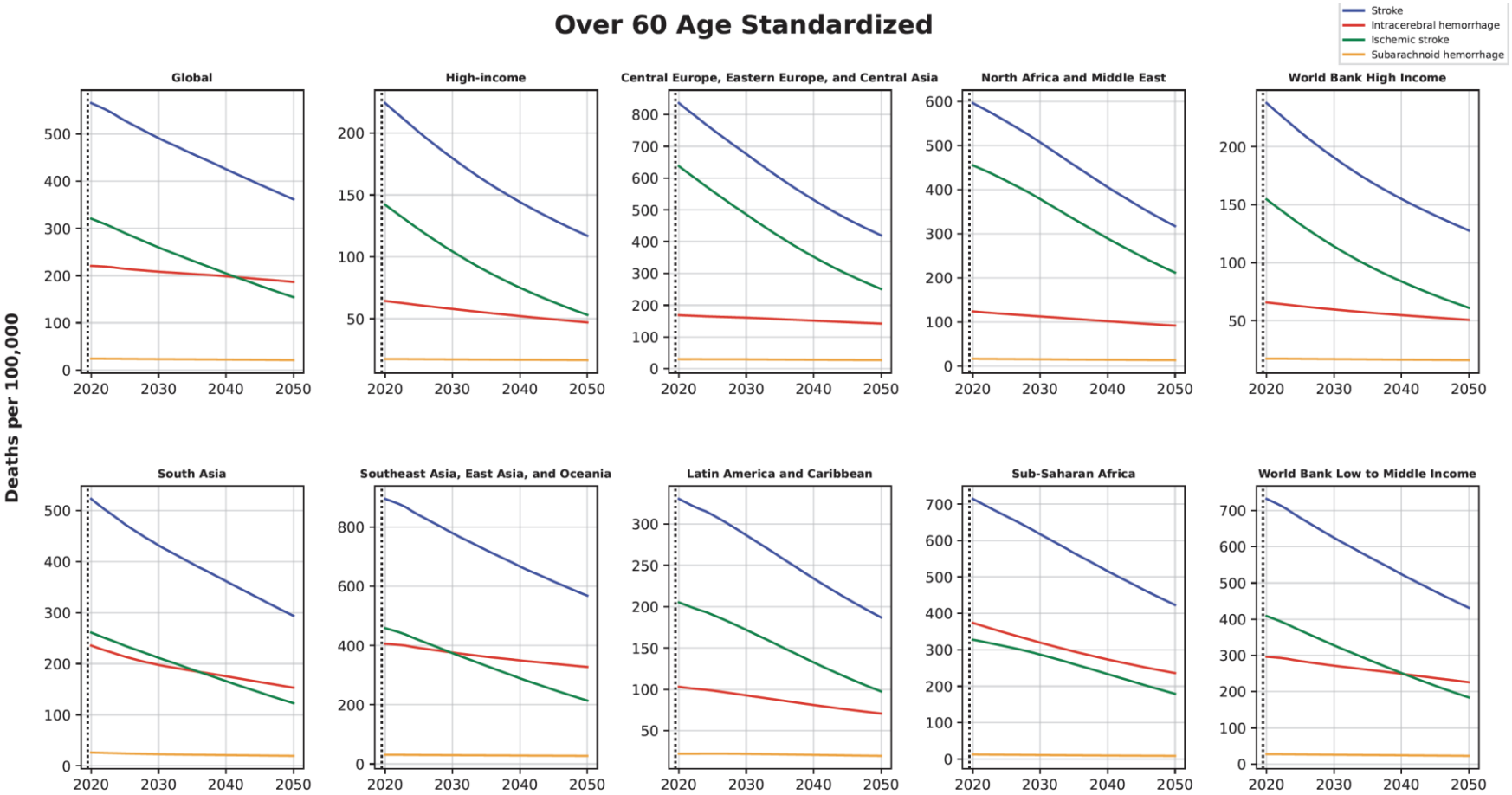
Supplementary Figure 3: Forecasts of stroke deaths (with 95% UI) globally by age group (<60 years, 60+ years), pathological types of stroke (ischaemic stroke, intracerebral haemorrhage, subarachnoid haemorrhage, total strokes), GBD regions and World Bank country income level, 2020-2050



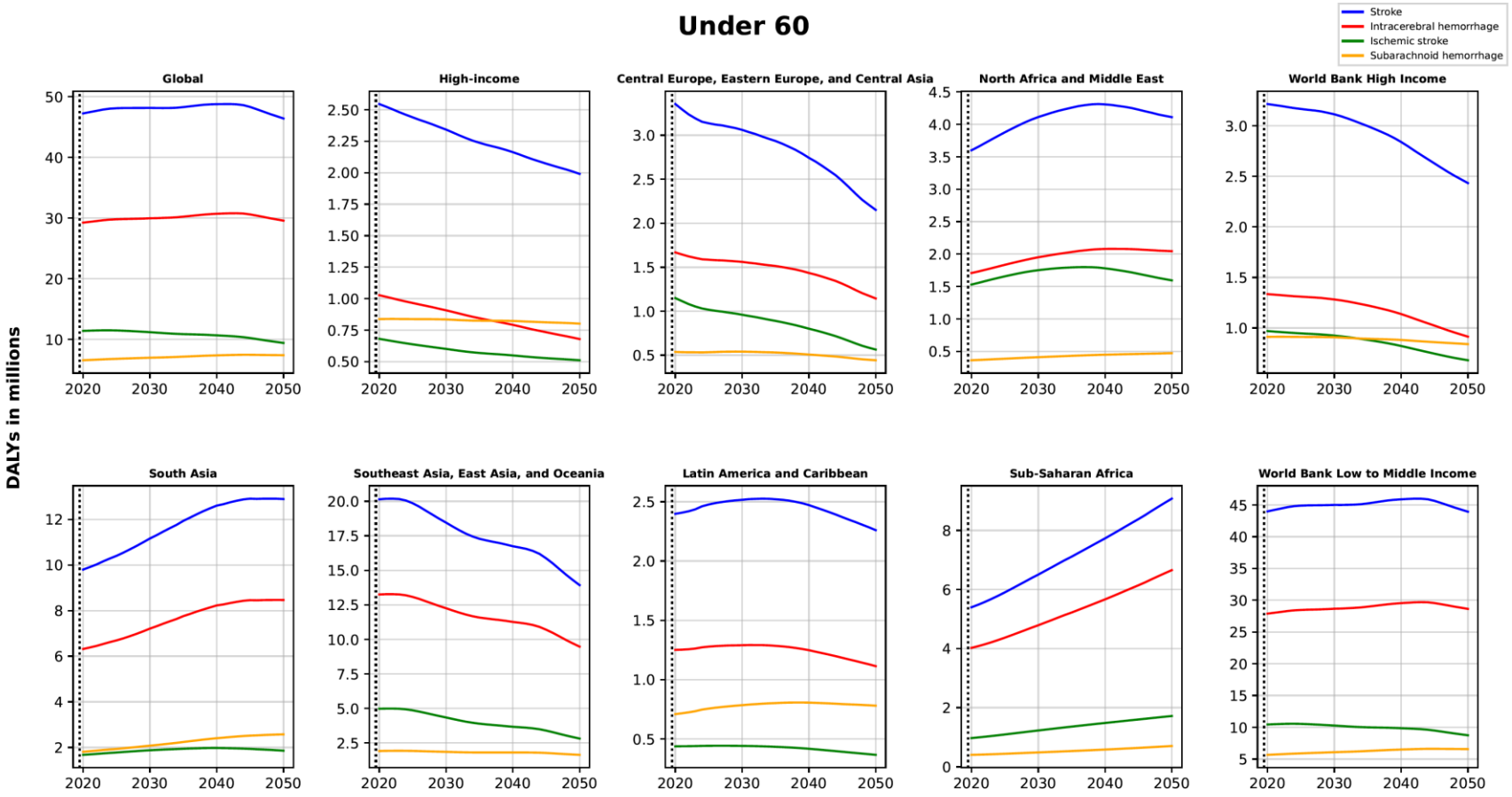

Over 60
Stroke
Intracerebral hemorrhage
Ischemic stroke
Subarachnoid hemorrhage
Deaths in millions
Global
High-income
Central Europe, Eastern Europe, and Central Asia
North Africa and Middle East
World Bank High Income
South Asia
Southeast Asia, East Asia, and Oceania
Latin America and Caribbean
Sub-Saharan Africa
World Bank Low to Middle Income

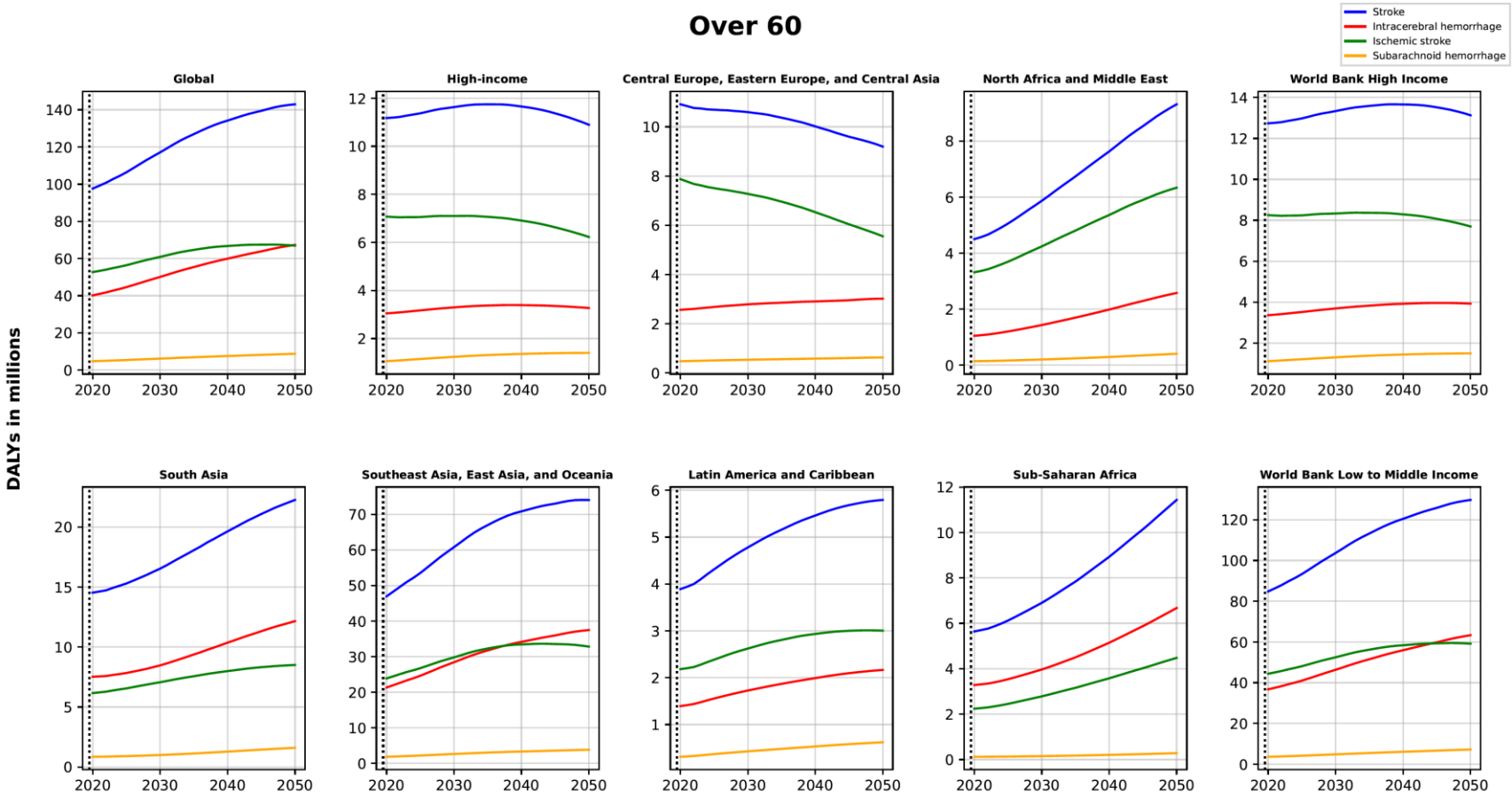
Supplementary Figure 4: Forecasts of age-standardized stroke deaths rates per 100,000 person-years (with 95% UI) globally by age group (<60 years, 60+ years), pathological types of stroke (ischaemic stroke, intracerebral haemorrhage, subarachnoid haemorrhage, total strokes), GBD regions and World Bank country income level, 2020-2050



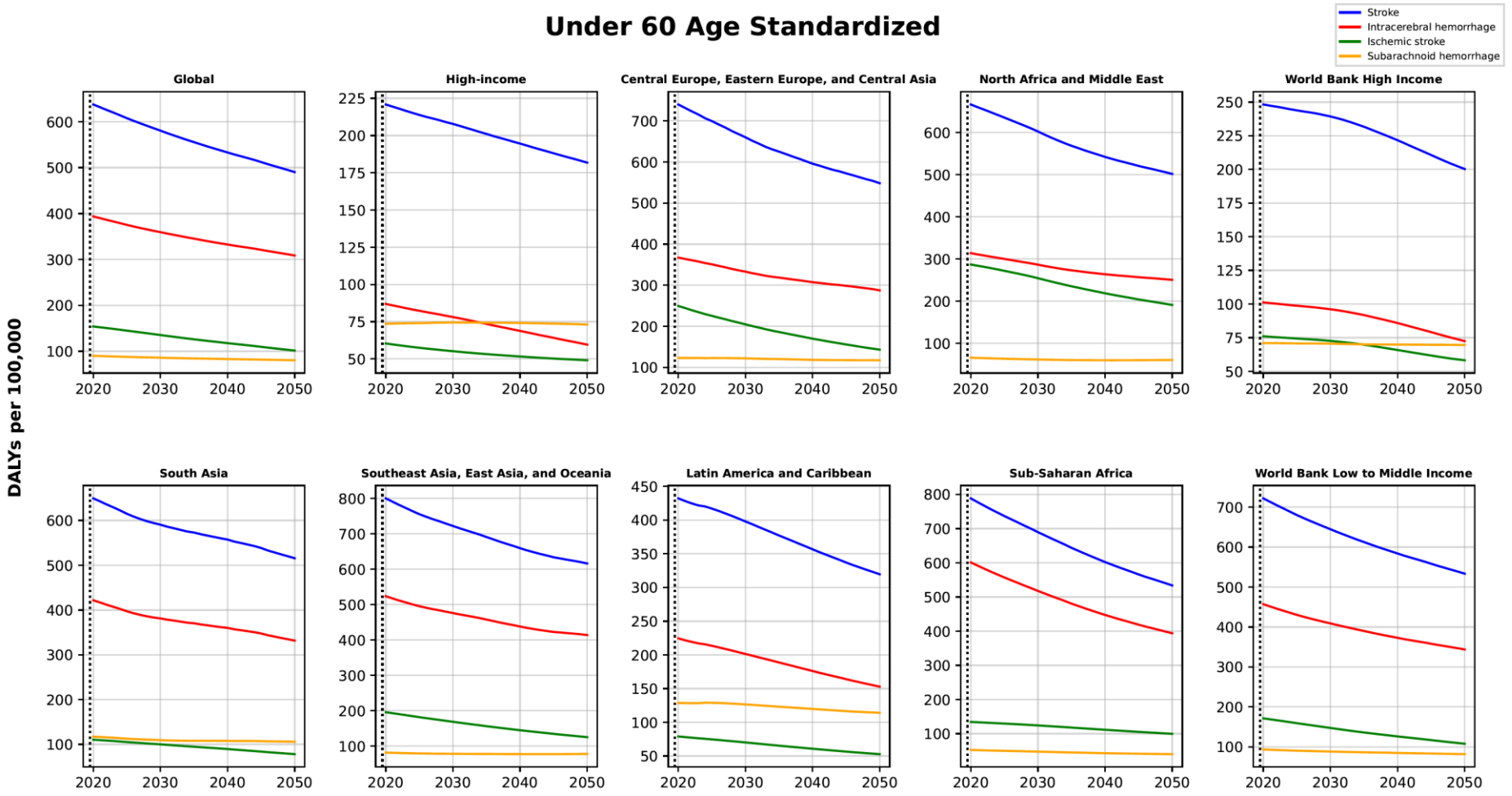

Over 60 Age Standardized
Stroke
Intracerebral hemorrhage
Ischemic stroke
Subarachnoid hemorrhage
Deaths per 100,000
Global
High-income
Central Europe, Eastern Europe, and Central Asia
North Africa and Middle East
World Bank High Income
South Asia
Southeast Asia, East Asia, and Oceania
Latin America and Caribbean
Sub-Saharan Africa
World Bank Low to Middle Income

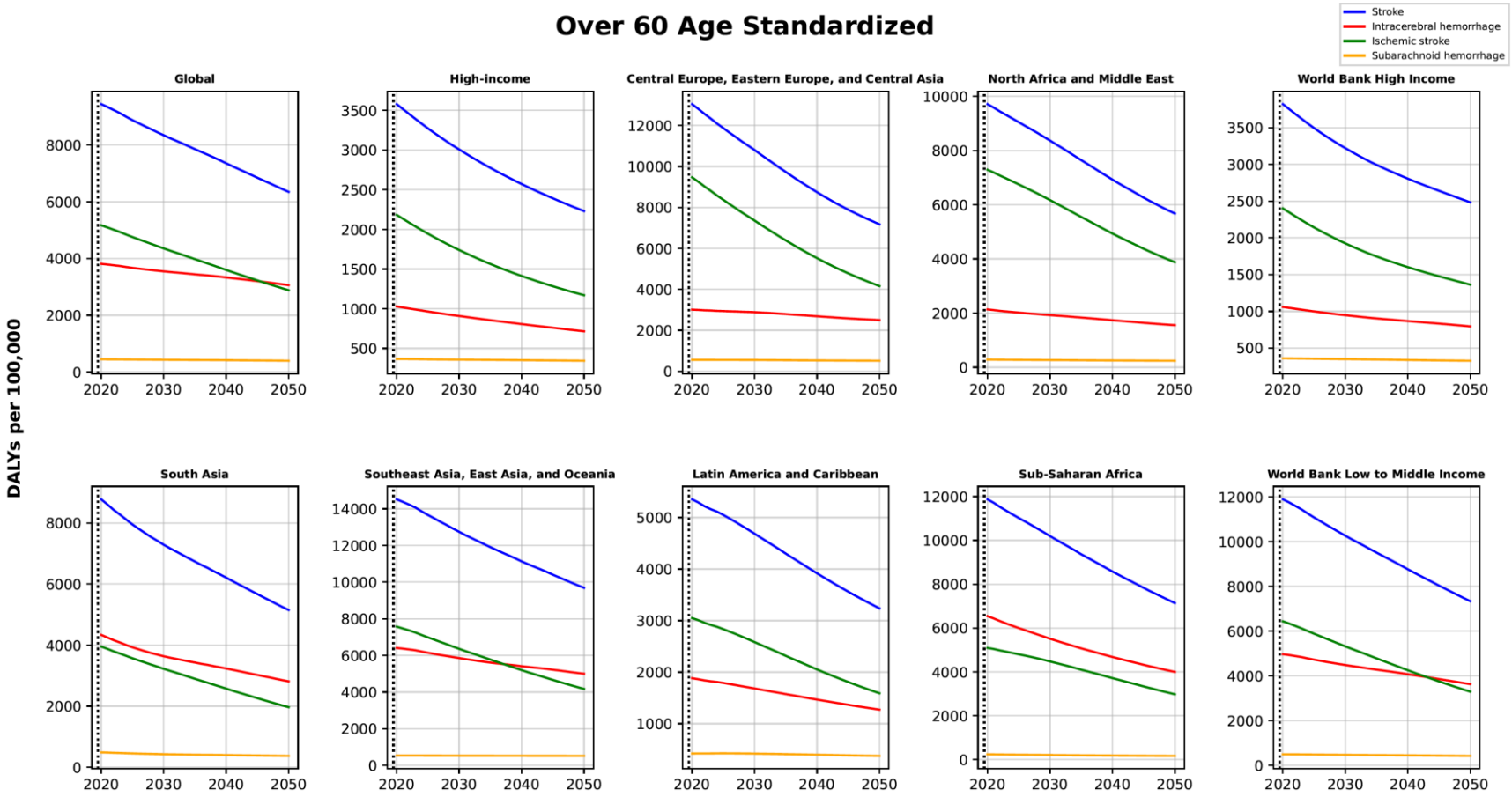
Supplementary Figure 5: Forecasts of DALYs counts globally by age group (<60 years, 60+ years), pathological types of stroke (ischaemic stroke, intracerebral haemorrhage, subarachnoid haemorrhage, total strokes), GBD regions and World Bank country income level, 2020-2050



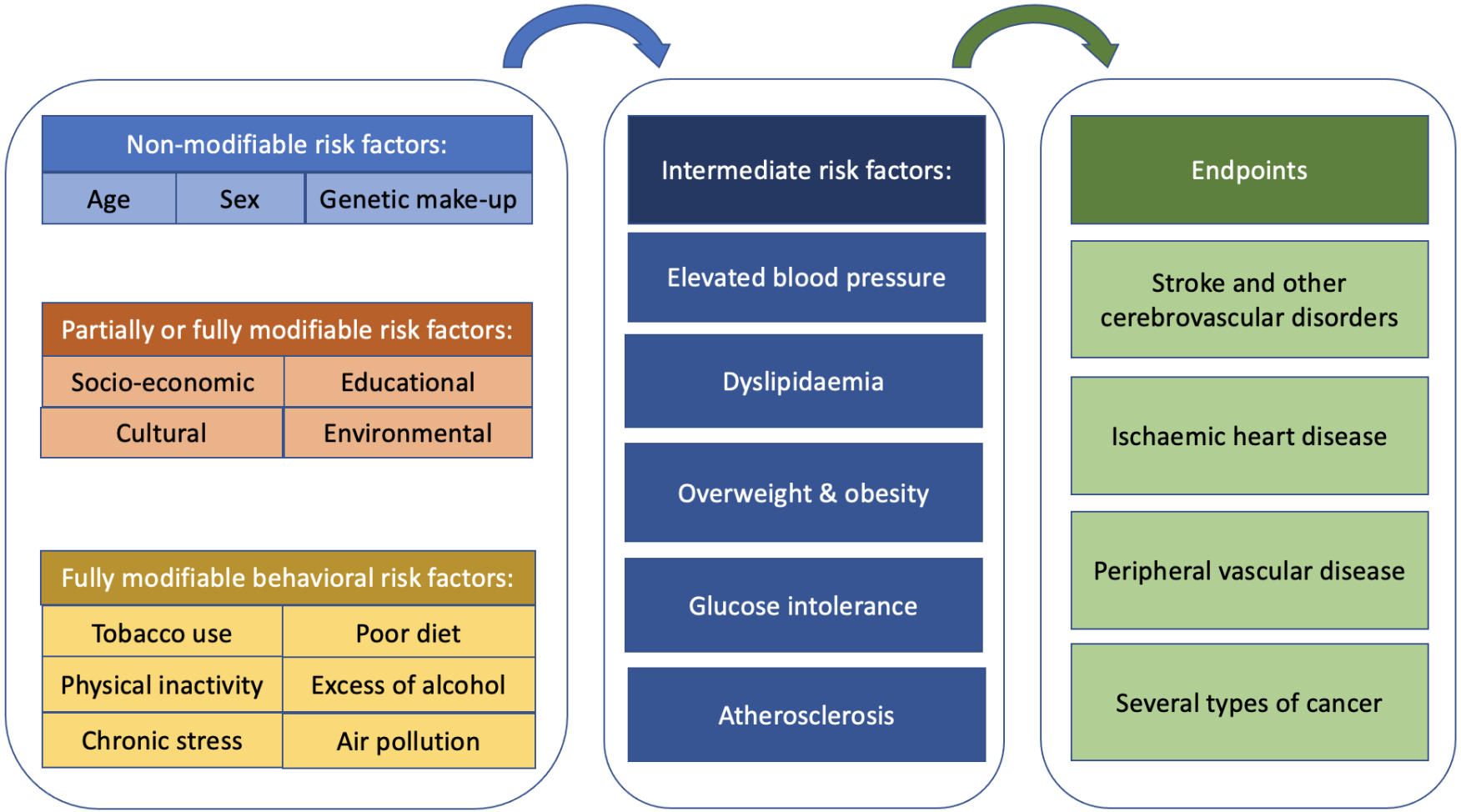

Over 60
Stroke
Intracerebral hemorrhage
Ischemic stroke
Subarachnoid hemorrhage
DALYs in millions
Global
High-income
Central Europe, Eastern Europe, and Central Asia
North Africa and Middle East
World Bank High Income
South Asia
Southeast Asia, East Asia, and Oceania
Latin America and Caribbean
Sub-Saharan Africa
World Bank Low to Middle Income

Supplementary Figure 6: Forecasts of age-standardized DALYs rates per 100,000 person-years globally by age group (<60 years, 60+ years), pathological types of stroke (ischaemic stroke, intracerebral haemorrhage, subarachnoid haemorrhage, total strokes), GBD regions and World Bank country income level, 2020-2050



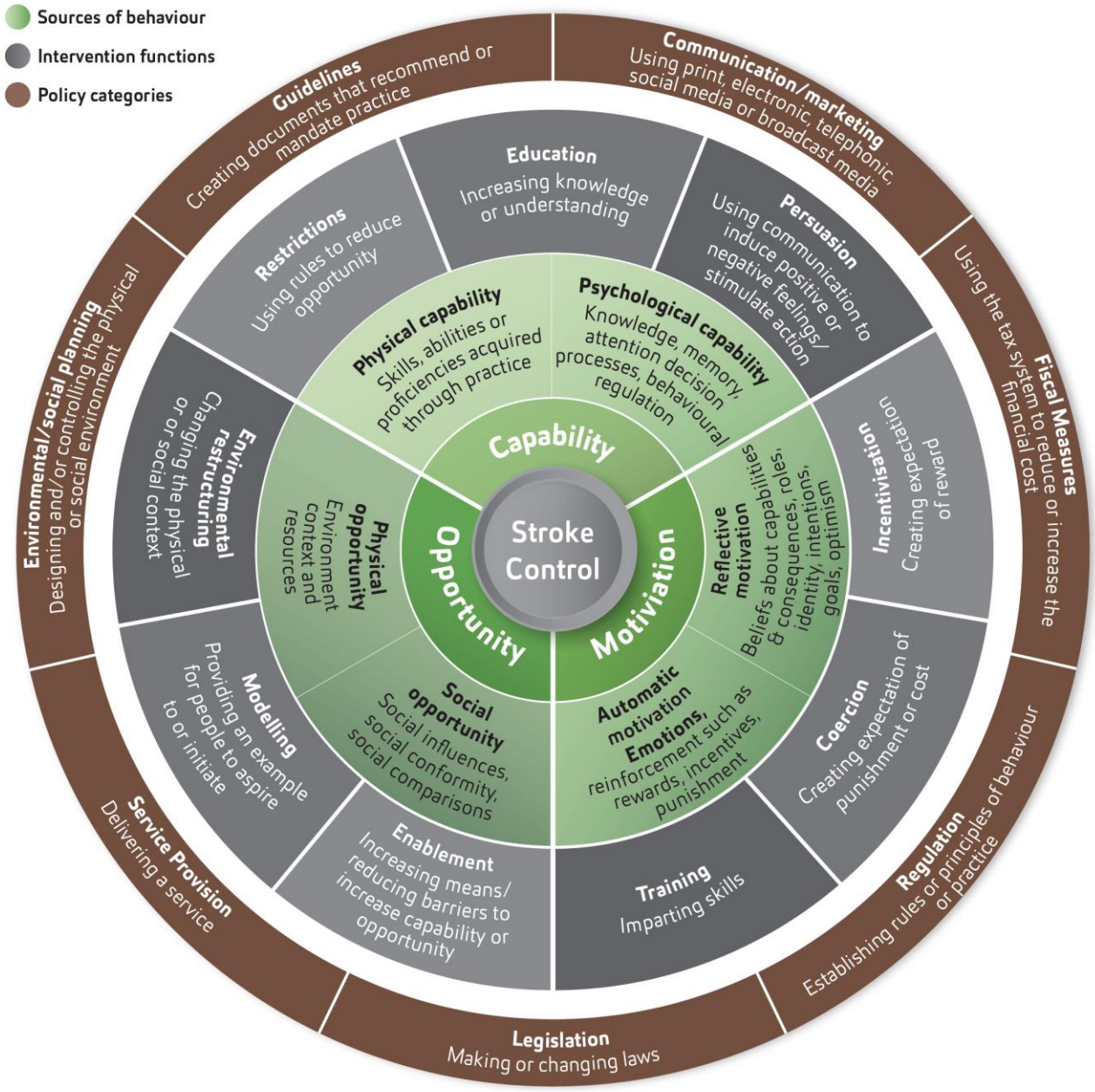

Over 60 Age Standardized
Stroke
Intracerebral hemorrhage
Ischemic stroke
Subarachnoid hemorrhage
DALYs per 100,000
Global
High-income
Central Europe, Eastern Europe, and Central Asia
North Africa and Middle East
World Bank High Income
South Asia
Southeast Asia, East Asia, and Oceania
Latin America and Caribbean
Sub-Saharan Africa
World Bank Low to Middle Income

Supplementary Figure 7. Preventing stroke and its major risk factors



Supplementary Figure 8: Behavioural Change Wheel

modified from Michie et al.[5]



Supplementary Figure 9 : Neurorehabilitation Services for Stroke

Range of services and care paradigm available at LMIC [eg Blossom Neurorehabilitation Center, Ibadan (Nigeria)] and HICs [eg BDH Klinik, Greifswald (Germany)]: In-patient and out-patient services to facilitate recovery and optimize quality of life of patients are provided by neurologists, physicians (eg cardiologists), neurosurgeons, physiotherapist, psychotherapists, speech and language therapists, occupational therapists, dietitians, nurses, medical officers, client service officers, amongst others. The Center pioneers and propagates Therapeutic services, Research, Enlightenment, Advocacy and conferences, and Training (TREAT) for neurorehabilitation in the region. However, there are a higher number of staff per category for BDH Klinik.

Physiotherapy Gymnasium of the BDH Klinik, Greifswald (Germany)

SUPPLEMENTARY TABLES

Supplementary Table 1. Forecasts of stroke related deaths (counts and rates per 100,000 person-years, with 95% UI) by age group (total, under 60 years old, 60+ years old), GBD super-regions and year (2020 and 2050)

GBD super-region	Metric	Year	All ages Mean (95% UI)	Age-Standardized (AS) Mean (95% UI)	Under 60 years old Mean (95% UI) (Rates reported as AS)	60+ years old Mean (95% UI) (Rates reported as AS)
Southeast Asia, East Asia, and Oceania	Counts	2020	3.06 (2.62-3.46)		0.44 (0.38-0.50)	2.62 (2.23-2.96)
		2050	4.94 (4.09-5.90)		0.30 (0.22-0.37)	4.65 (3.83-5.51)
	Rates	2020	141.27 (121.11-159.81)	127.68 (108.49-144.44)	16.85 (14.51-19.24)	895.16 (761.93-1014.07)
		2050	232.25 (192.44-277.01)	82.54 (68.37-98.42)	12.39 (9.35-15.59)	568.34 (467.50-677.61)
Central Europe, Eastern Europe, and Central Asia	Counts	2020	0.75 (0.68-0.83)		0.07 (0.07-0.08)	0.68 (0.61-0.75)
		2050	0.66 (0.56-0.77)		0.04 (0.03-0.07)	0.61 (0.52-0.71)
	Rates	2020	180.57 (162.50-198.46)	119.26 (107.35-131.04)	15.71 (13.89-17.55)	836.25 (751.08-917.84)
		2050	164.32 (140.17-192.41)	62.53 (51.83-75.21)	10.98 (6.89-16.45)	419.53 (357.46-492.06)
High-income regions	Counts	2020	0.81 (0.69-0.91)		0.05 (0.04-0.05)	0.77 (0.64-0.86)
		2050	0.78 (0.64-0.86)		0.03 (0.03-0.04)	0.75 (0.61-0.86)
	Rates	2020	74.69 (63.41-83.43)	31.49 (27.14-34.92)	3.66 (3.45-3.93)	224.15 (190.90-250.25)
		2050	69.50 (56.73-80.64)	17.21 (14.17-20.20)	2.80 (2.18-3.61)	116.96 (96.01-136.27)
Latin America and Caribbean	Counts	2020	0.29 (0.25-0.32)		0.05 (0.05-0.07)	0.23 (0.20-0.26)
		2050	0.42 (0.32-0.55)		0.05 (0.03-0.08)	0.37 (0.28-0.48)
	Rates	2020	48.58 (43.00-53.88)	49.61 (43.68-54.98)	9.07 (8.07-10.24)	330.39 (285.51-367.33)
		2050	61.80 (46.78-80.77)	29.26 (21.48-39.93)	6.49 (4.08-10.31)	186.95 (140.68-246.18)
North Africa and Middle East	Counts	2020	0.32 (0.28-0.36)		0.07 (0.06-0.08)	0.25 (0.22-0.28)
		2050	0.57 (0.43-0.80)		0.08 (0.05-0.12)	0.50 (0.38-0.67)
	Rates	2020	51.42 (45.70-57.70)	86.57 (77.13-96.40)	12.94 (10.83-15.52)	596.41 (531.95-660.90)
		2050	71.37 (52.93-98.35)	48.23 (36.12-65.80)	9.34 (6.05-14.37)	317.51 (243.27-418.31)
Sub-Saharan Africa	Counts	2020	0.41 (0.36-0.46)		0.11 (0.09-0.13)	0.30 (0.26-0.33)
		2050	0.78 (0.64-0.94)		0.18 (0.13-0.26)	0.60 (0.50-0.69)

	Rates	2020	36.80 (32.30-41.65)	105.19 (92.64-118.00)	17.20 (14.15-20.43)	714.50 (625.28-798.08)
		2050	38.62 (31.51-46.47)	63.06 (52.63-73.21)	11.07 (8.01-15.37)	423.04 (357.14-484.48)
South Asia	Counts	2020	0.99 (0.85-1.15)		0.21 (0.18-0.25)	0.78 (0.67-0.90)
		2050	1.56 (1.18-2.04)		0.29 (0.19-0.44)	1.27 (0.97-1.62)
	Rates	2020	54.30 (46.78-63.19)	78.65 (67.53-91.29)	14.49 (12.34-17.01)	522.96 (447.36-605.91)
		2050	75.24 (56.80-98.17)	46.82 (35.04-61.58)	11.14 (7.30-17.00)	293.92 (222.43-374.88)

Supplementary Table 2: Forecasts of stroke related DALYs (counts and rates per 100,000 person-years, with 95% UI) by age group (total, under 60 years old, 60+ years old), GBD super-regions and year (2020 and 2050)

GBD super-region	Metric	Year	All ages Counts/rates (95% UI)	Age-Standardized (AS) rates (95% UI)	Under 60 years old Mean (95% UI) (Rates reported as AS)	60+ years old Mean (95% UI) (Rates reported as AS)
Southeast Asia, East Asia, and Oceania	Counts	2020	67.10 (58.43-75.85)		20.14 (17.56-22.99)	46.95 (40.65-53.10)
		2050	87.98 (74.61-103.26)		13.93 (11.08-17.13)	74.06 (62.82-86.76)
	Rates	2020	3098.72 (2698.22-3503.00)	2531.07 (2210.74-2852.43)	800.34 (695.10-911.04)	14515.87 (12576.37-16386.97)
		2050	4133.29 (3505.36-4851.04)	1760.79 (1481.49-2070.58)	616.17 (486.88-760.68)	9686.91 (8255.21-11348.06)
Central Europe, Eastern Europe, and Central Asia	Counts	2020	14.27 (12.85-15.64)		3.35 (2.98-3.76)	10.92 (9.86-11.94)
		2050	11.35 (9.72-13.10)		2.15 (1.59-2.86)	9.20 (8.09-10.40)
	Rates	2020	3415.23 (3075.35-3742.91)	2292.02 (2064.62-2511.35)	739.83 (655.81-829.48)	13040.44 (11771.67-14273.44)
		2050	2844.59 (2435.30-3283.44)	1384.40 (1148.25-1660.84)	548.22 (401.81-739.17)	7174.71 (6260.53-8178.47)
High-income regions	Counts	2020	13.72 (12.28-14.96)		2.54 (2.30-2.83)	11.17 (9.89-12.27)
		2050	12.89 (10.93-14.57)		1.99 (1.67-2.41)	10.89 (9.31-12.32)
	Rates	2020	1261.84 (1129.63-1375.59)	644.58 (578.00-706.37)	220.88 (199.20-247.14)	3578.56 (3178.25-3923.08)
		2050	1150.90 (976.25-1300.84)	440.32 (375.18-507.88)	181.82 (150.95-222.68)	2230.38 (1893.56-2519.85)
Latin America and Caribbean	Counts	2020	6.29 (5.69-6.96)		2.40 (2.13-2.69)	3.89 (3.49-4.32)
		2050	8.05 (6.47-10.20)		2.26 (1.66-3.20)	5.79 (4.71-7.09)
	Rates	2020	1069.91 (951.33-1166.16)	1053.01 (951.34-1166.16)	432.15 (383.19-484.38)	5352.31 (4787.79-5951.93)
		2050	1193.46 (958.46-1511.55)	687.61 (539.05-900.33)	319.56 (231.30-460.02)	3236.32 (2639.65-4016.78)
North Africa and Middle East	Counts	2020	8.10 (7.15-9.10)		3.60 (3.03-4.23)	4.50 (4.02-4.93)
		2050	13.42 (10.51-17.50)		4.11 (2.95-5.78)	9.31 (7.45-11.96)
	Rates	2020	1313.40 (1159.24-1476.81)	1807.75 (1596.44-2017.88)	666.19 (561.98-781.43)	9712.70 (8694.54-10725.79)
		2050	1653.14 (1294.32-2154.86)	1154.33 (895.49-1521.04)	501.50 (358.19-710.24)	5674.98 (4573.65-7234.60)
	Counts	2020	11.04 (9.57-12.59)		5.39 (4.56-6.33)	5.64 (4.99-6.31)

Sub-Saharan Africa		2050	20.51 (16.89-24.98)		9.07 (6.90-12.08)	11.43 (9.86-13.04)
	Rates	2020	998.46 (865.76-1138.49)	2187.52 (1927.11-2473.86)	788.34 (666.08-924.39)	11876.43 (10522.85-13271.60)
		2050	1009.79 (831.57-1229.82)	1367.36 (1151.33-1606.96)	533.78 (407.41-709.48)	6576.47 (5670.19-7498.59)
South Asia	Counts	2020	24.33 (21.40-28.18)		9.80 (8.50-11.43)	14.53 (12.65-16.89)
		2050	35.16 (27.82-45.23)		12.89 (9.50-17.72)	22.26 (17.97-27.69)
	Rates	2020	1336.09 (1174.54-1547.30)	1674.76 (1467.14-1945.97)	649.37 (562.23-758.80)	8775.28 (7640.72-10189.38)
		2050	1690.59 (1338.26-2175.00)	1100.40 (865.51-14.25.27)	515.61 (379.82-711.18)	5149.84 (4149.83-6403.86)

Supplementary Table 3: Global forecasts of stroke related deaths and DALYs (counts and age-standardized rates per 100,000 person-years, with 95% UI) by stroke type (IS – ischaemic stroke, ICH – intracerebral haemorrhage, SAH – subarachnoid haemorrhage), age group (total, under 60 years old, 60+ years old), and year (2020 and 2050)

Type of stroke	Year	Metric	Projected estimates of deaths: Mean (95% UI)			Projected estimates of DALYs: Mean (95% UI)		
			Under 60 years	60+ years	Total	Under 60 years	60+ years	Total
IS	2020	Counts	0.18 (0.16-0.21)	3.12 (2.81-3.38)	3.31 (2.98-3.58)	11.42 (9.81-13.09)	52.70 (47.57-57.67)	64.11 (57.47-70.40)
	2050		0.11 (0.08-0.17)	3.87 (3.21-4.60)	4.00 (3.29-4.75)	9.42 (7.33-11.81)	66.91 (56.56-78.28)	76.33 (64.25-89.78)
	2020	Age-standardized rates	2.45 (2.17-2.74)	320.77 (286.71-347.95)	42.62 (38.23-46.20)	153.88 (132.32-176.66)	5170.52 (4665.88-5662.86)	786.92 (706.13-864.10)
	2050		1.16 (0.77-1.72)	154.46 (127.28-184.80)	20.50 (16.81-24.68)	101.42 (78.77-127.76)	2881.74 (2423.50-3389.98)	452.26 (376.72-535.54)
ICH	2020	Counts	0.68 (0.61-0.74)	2.25 (2.01-2.45)	2.93 (2.65-3.19)	29.25 (26.41-31.99)	40.15 (36.52-43.54)	69.40 (63.54-75.35)
	2050		0.70 (0.56-0.89)	4.39 (3.82-4.95)	5.10 (4.42-5.78)	29.57 (23.32-37.67)	67.32 (58.24-77.27)	96.90 (82.66-113.95)
	2020	Age-standardized rates	10.08 (9.06-10.97)	212.06 (189.37-230.59)	35.75 (32.20-38.85)	393.75 (355.16-430.37)	3811.23 (3462.76-4133.93)	824.99 (756.20-895.45)
	2050		9.86 (7.78-12.53)	208.80 (181.83-235.46)	29.78 (35.70-34.29)	308.55 (241.47-397.86)	3063.13 (2636.05-3545.24)	656.14 (551.13-778.87)
SAH	2020	Counts	0.13 (0.11-0.16)	0.25 (0.21-0.27)	0.38 (0.33-0.42)	6.57 (5.66-7.78)	4.76 (4.20-5.26)	11.33 (9.96-12.78)
	2050		0.16 (0.10-0.23)	0.49 (0.35-0.68)	0.65 (0.47-0.89)	7.41 (4.69-10.86)	8.71 (6.18-12.03)	16.12 (11.19-22.66)
	2020		1.81 (1.55-2.17)	24.16 (20.90-26.72)	4.63 (4.07-5.15)	90.00 (77.50-106.87)	452.89 (400.11-499.95)	135.79 (119.63-153.19)

	2050	Age-standardized rates	1.63 (1.03-2.46)	21.15 (15.03-29.17)	4.09 (2.87-5.68)	80.32 (50.56-118.35)	400.71 (280.68-555.91)	120.75 (81.48-172.88)

Supplementary Table 4. Income losses due to incident stroke cases in 2017 and 2050 (in billions 2017 US$)

World Bank country classification by income level	2017	2050
High-Income countries	289.1	281.0
Upper Middle-Income countries	241.0	206.8-432.8
Lower Middle-Income countries	43.6	147.6
Low Income countries	2.0	8.6
Global Total	575.7	644.0-870.0

Note: 2017 estimates are from Table 4 of the Supplementary Appendix in Owolabi et. al.[1] 2050 estimates are based on projected gross domestic product (GDP) per worker estimates for 2050 as outlined in the accompanying methodological note, with the range for Upper Middle-Income Countries reflecting two different assumptions about projected rate of growth of GDP per capita in China.[113]

Supplementary Table 5. Direct Costs and income losses due to stroke in 2017 and 2050 (in billions 2017 US$)

World Bank country classification by income level	2017 (Low)	2017 (High)	2050 (Low)	2050 (High)
High-Income countries	417.0	597.6	436.6-655.9	578.3-997.0
Upper Middle-Income countries	279.1	410.0	273.5-743.6	334.2-1,026.4
Lower Middle-Income countries	48.3	64.8	159.5-200.4	170.4-252.5
Low Income countries	2.6	4.9	11.2-22.0	13.5-34.1
Global Total	745.9	1,077.2	880.8-1,621.9	1,096.4-2,310.0

Supplementary Table 6. Coverage, current capacity for stroke surveillance, and estimated unmet needs

Country	Population size (in millions) [a]	Last risk factors surveillance and assessments conducted [b]						National [c] stroke registry	National surveillance of risk factors for stroke	Surveillance of stroke incidence through national registries
		Survey name (year), reference	Anthropology	BP	Lab tests	Behavioural surveillance	Metabolic risks			
Afghanistan	48.09	STEPS (2018)[114]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Albania	2.73	EHIS (2020)[115]	✓	✓	x	✓	✓	x	Recent survey undertaken, but lacking biochemical measures	National capacity for stroke surveillance through registries required
Algeria	50.36	STEPS (2016-2017)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Andorra	0.08	NHS (2011)[116]	✓	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Angola	44.83	DHS (2015-16)[117]	x	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Anguilla	0.02	STEPS (2016)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Antigua and Barbuda [e]	0.10	-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Argentina	49.24	National Survey of Chronic Disease Risk Factors (CDRF; 2018)[118]	✓	✓	x	✓	✓	✓	Recent survey undertaken, but lacking biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide
Armenia	2.97	DHS (2015-2016)[119]	x	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Aruba	0.11	STEPS (2006)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Australia	28.06	National Health Survey (NHS; 2017-2018)[119]	✓	✓	x	✓	✓	✓	Recent survey undertaken, but lacking biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide
Austria	9.06	EHIS (2019)[115]	✓	x	x	✓	✓	✓	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide
Azerbaijan	10.65	STEPS (2017)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Bahamas	0.43	STEPS (2011-2012)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Bahrain	2.01	STEPS (2007)[114]	✓	✓	✓	✓	✓	✓	More comprehensive and/or recent survey required	Have capacity for national stroke surveillance through registries
Bangladesh	178.99	DHS (2017-2018)[120]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Barbados	0.29	STEPS (2007)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required

Belarus	9.16	STEPS (2016-2017)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Belgium	11.84	EHIS & EHES (2018)[115,121]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Belize	0.47	Central America Diabetes Initiative (CAMDI; 2009)[122]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Benin	15.67	DHS (2017-2018)[123]	✓	x	x	x	x	x	Recent survey undertaken, but lacking measurements of BP and other important risk factors	National capacity for stroke surveillance through registries required
Bermuda	0.06	STEPS (2014)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Bhutan	0.84	STEPS (2019)[114]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Bolivia	13.24	DHS (2016)[124]	✓	x	x	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Bosnia and Herzegovina	3.13	NHS (2012)[125]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Botswana	2.77	STEPS (2014)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Brazil	223.85	NHS (2019)[126]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
British Virgin Islands	0.03	STEPS (2009)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Brunei Darussalam	0.47	STEPS (2015-2016)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Bulgaria	6.41	EHIS (2019)[115,127]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Burkina Faso	27.40	STEPS (2013)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Burundi	15.77	DHS (2016-2017)[128]	x	x	x	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Cambodia	18.78	DHS (2014)[129]	x	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Cameroon	33.77	DHS (2018-2019)[130]	x	x	x	x	x	x	Recent survey lacks measures of stroke risk factors	National capacity for stroke surveillance through registries required
Canada	40.92	Canadian Health Measures Survey (CHMS; 2018-2019)[131]	✓	✓	✓	✓	✓	✓	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries could be expanded nationwide
Cape Verde	0.61	STEPS (2007)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Cayman Islands	0.07	STEPS (2012)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Central African Republic	5.94	STEPS (2017)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Chad	21.69	DHS (2014-15)[132]	x	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required

Chile	19.46	CNHS (2016-2017)[133]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
China	1430.16	China National Health Survey (CHNS; 2015-2017)[134]	✓	✓	✓	✓	✓	✓	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries could be expanded nationwide
Colombia	53.42	DHS (2015-2016)[135]	✓	x	x	x	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Comoros	1.06	DHS (2012)[136]	x	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Congo	7.02	DHS (2011-12)[137]	x	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Congo, Dem. Rep.	120.05	DHS (2013-2014)[138]	x	x	x	x	x	x	Recent survey lacks measures of stroke risk factors	National capacity for stroke surveillance through registries required
Cook Islands	0.02	STEPS (2013-2015)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Costa Rica	5.47	CAMDI; 2002-2006)[139]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Cote d'Ivoire	33.71	DHS (2011-2012)[140]	x	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Croatia	3.70	SHARE (Wave 8; 2019-2020);[141] EHIS (2019)[115]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Cuba	11.14	-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Cyprus	1.27	EHIS (2019)[115]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Czechia	10.69	NIPH (2020); SHARE (Wave 8; 2019-2020);[141] EHIS & EHES (2019)[115]	✓	✓	✓	✓	✓	✓	Recent and comprehensive survey undertaken	Have capacity for national stroke surveillance through registries
Democratic People's Republic of Korea	26.65	STEPS (2008)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Denmark	6.03	DNHS (2017)[142] SHARE (Wave 8; 2019-2020);[141] EHIS (2019)[115]	✓	x	x	✓	✓	✓	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide
Djibouti	1.12	-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Dominica	0.07	STEPS (2008)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Dominican Republic	11.77	DHS (2013)[143]	✓	x	x	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Ecuador	19.82	STEPS (2018)[114]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Egypt, Arab Rep.	120.83	DHS (2015)[144]	✓	✓	x	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
El Salvador	6.78	CAMDI (2011)[139]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required

Equatorial Guinea	1.87	DHS (2011)[145]	✓	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Eritrea	4.24	STEPS (2004)[114]	✓	✓	x	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Estonia	1.28	EHIS (ETeU2019),[115,146] SHARE (Wave 8; 2019-2020)[141]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Eswatini	1.30	STEPS (2014)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Ethiopia	144.94	DHS (2019)[147]	✓	x	x	x	x	x	Recent survey undertaken, but lacking BP measures and other important risk factors	National capacity for stroke surveillance through registries required
Falkland Islands (Malvinas)	0.00	NHS (2019)[148]	x	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Fiji	0.97	STEPS (2011)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Finland	5.55	EHIS (2019)[149] &NHS (2017)[150]	✓	✓	✓	✓	✓	✓	Recent and comprehensive survey undertaken	Have capacity for national stroke surveillance through registries
France	68.67	EHIS (2019)[115]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
French Guiana	0.44	-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Gabon	2.74	DHS (2012)[151]	✓	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Gambia	3.17	DHS (2019-20)[152]	x	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Georgia	3.58	STEPS (2016)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Germany	82.21	EHIS (2020)[115]	✓	x	x	✓	✓	✓	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide
Ghana	37.83	DHS (2014)[153]	✓	✓	x	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Greece	10.20	EHIS (2019)[115,154]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Grenada	0.12	STEPS (2010-2011)[114]	✓	✓	x	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Guadeloupe	0.40	-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Guatemala	19.88	STEPS (2015)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Guinea	17.02	DHS (2018)[155]	x	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Guinea-Bissau	2.46	-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required

Guyana	0.82	STEPS (2016)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Haiti	12.73	DHS (2016-2017)[156]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Honduras	11.45	DHS (2011-2012)[157]	✓	x	x	x	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Hong Kong	7.86	PHS (2020)[158]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Hungary	9.40	SHARE (Wave 8; 2019-2020)[159]; EHIS (2019)[115]	✓	x	x	✓	✓	✓	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide
Iceland	0.39	EHIS (2019)[115]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
India	1503.64	DHS (2019-2021)[160]	✓	✓	✓	✓	✓	✓	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries could be expanded nationwide
Indonesia	299.20	DHS (2017)[161]	x	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Iran, Islamic Rep.	92.66	STEPS (2016)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Iraq	50.19	STEPS (2015)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Ireland	5.27	Healthy Ireland Survey (2021);[162] EHIS (2019)[115]	✓	x	x	✓	✓	✓	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide
Israel	10.61	Israel National Health Survey (INHIS; 2014)[163]	✓	✓	✓	✓	✓	✓	More comprehensive and/or recent survey required	Have capacity for national stroke surveillance through registries
Italy	57.60	SHARE (Wave 8; 2019-2020)[159]; EHIS (2019)[115]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Jamaica	3.05	Jamaica Health and Lifestyle Survey (2016-2017)[164]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Japan	119.58	NHNS (2019)[165]	✓	✓	✓	✓	✓	✓	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries could be expanded nationwide
Jordan	10.65	STEPS (2019)[114]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Kazakhstan	20.66	Aktobe Oblast STEPS (2016)[166]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Kenya	66.45	STEPS (2015)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Kiribati	0.14	STEPS (2015-2016)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Korea, Rep.	51.44	Korea National Health and Nutrition Survey (KNHANES; 2019)[167]	✓	✓	x	✓	x	✓	Recent survey undertaken, but lacking biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide

Kuwait	4.75	STEPS (2014)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Kyrgyz Republic	7.53	STEPS (2013)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Lao People's Democratic Republic	8.23	DHS (2017)[168]	x	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Latvia	1.74	EHIS (2019)[115]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Lebanon	6.20	STEPS (2016-2017)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Lesotho	2.33	DHS (2014)[169]	✓	✓	x	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Liberia	6.37	DHS (2019-20)[170]	x	x	x	✓	x	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Libyan Arab Jamahiriya	7.61	STEPS (2009)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Lithuania	2.60	EHIS (2019)[127]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Luxembourg	0.69	EHIS (2019)[127]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Macau	0.73	-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Madagascar	35.62	DHS (2021)[171]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Malawi	24.85	STEPS (2017)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Malaysia	36.10	National Health and Morbidity Survey (NHMS; 2020)[172]	✓	✓	✓	✓	✓	✓	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries could be expanded nationwide
Maldives	0.52	DHS (2016-2017)[173]	✓	x	x	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Mali	26.96	DHS (2018)[174]	x	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Malta	0.52	EHIS (2020)[127]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Marshall Islands	0.06	STEPS (2017-2018)[114]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Martinique	0.367	-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Mauritania	5.97	DHS (2021)[175]	x	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Mauritius	1.27	DHS (2015)[176]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Mayotte	0.343	-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required

Mexico	140.88	ENSANUT-MC (2016)[177]	✓	✓	✓	✓	✓	✓	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries could be expanded nationwide
Micronesia (Federated States of)	0.13	STEPS (2016)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Moldova	2.48	STEPS (2013)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Monaco	0.04	-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Mongolia	3.72	STEPS (2019)[114]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Montserrat	0.005	-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Morocco	40.89	STEPS (2017-2018)[114]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Mozambique	41.19	STEPS (2014-2015)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Myanmar	58.48	DHS (2015-2016)[178]	x	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Namibia	3.01	DHS (2013)[179]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Nauru	0.01	STEPS (2004)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Nepal	33.39	STEPS (2019)[114]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Netherlands	17.76	EHIS (2019)[127]	✓	x	x	✓	✓	✓	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide
New Zealand	5.43	New Zealand Health Survey (NZHS; 2020-2021)[180]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Nicaragua	7.39	CAMDI (2011)[139]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Niger	34.85	STEPS (2021)[114]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Nigeria	262.98	DHS (2018)[181]	✓	x	x	✓	x	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Niue	0.00	STEPS (2011)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
North Macedonia	2.03	National Nutrition Survey (2011)[182]	✓	x	x	x	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Norway	5.80	Survey of Living Conditions on Health (2019)[183]	✓	x	x	✓	✓	✓	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide
Occupied Palestinian Territory	6.74	STEPS (2010-2011)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required

Oman	5.94	STEPS (2017)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Pakistan	262.96	DHS (2017-2018)[184]	✓	x	x	x	x	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Palau	0.02	STEPS (2016)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Panama	4.93	Panama Living Standard Measurement Survey (PLSMS; 2003)[185]	✓	x	x	x	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Papua New Guinea	10.71	DHS (2016-2018)[186]	✓	x	x	✓	x	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Paraguay	7.95	STEPS (2011)[114]	✓	x	x	x	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Peru	36.03	DHS (2020)[187]	✓	✓	x	✓	✓	x	Recent survey undertaken, but lacking biochemical measures	National capacity for stroke surveillance through registries required
Philippines	123.70	DHS (2017)[188]	x	x	x	x	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Poland	36.87	EHIS (2019)[115]	✓	x	x	✓	✓	✓	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide
Portugal	10.01	EHIS (2019)[115]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Puerto Rico	3.30	The Behavioural Risk Factor Surveillance System (BRFSS; 2022)[189]	x	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Qatar	3.33	STEPS (2012)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Reunion		-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Rodrigues		-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Romania	18.31	EHIS (2019)[115]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Russian Federation	140.86	Russia Longitudinal Monitoring Survey (RLMS-HSE; 2020)[190]	✓	x	x	✓	✓	✓	Recent survey undertaken, but lacking BP and biochemical measures	Have capacity for national stroke surveillance through registries
Rwanda	16.23	DHS (2019-20)[191]	x	x	x	✓	x	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Ryu Kyu Islands		-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Saint Kitts and Nevis	0.06	STEPS (2007)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Saint Lucia	0.19	STEPS (2012)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Saint Pierre and Miquelon	0.005		-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required

Saint Vincent and Grenadines	0.11	STEPS (2013-2014)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Samoa	0.22	STEPS (2013)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
San Marino	0.03		-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Sao Tome and Principe	0.27	DHS (2008-2009)[192]	x	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Saudi Arabia	39.32	NHS (2019)[193]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Senegal	21.55	DHS (2019)[194]	x	x	x	x	x	x	Recent survey undertaken, but lacking measurements of BP other important risk factors	National capacity for stroke surveillance through registries required
Serbia	6.47	Serbian National Health Survey (SNHS; 2019);[195] EHIS (2019)[115]	✓	✓	x	✓	✓	x	Recent survey undertaken, but lacking biochemical measures	National capacity for stroke surveillance through registries required
Seychelles	0.10	STEPS (2013)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Sierra Leone	9.65	DHS (2019)[196]	✓	x	x	✓	x	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Singapore	5.80	National Population Health Survey (NPHS; 2019-2020)[197]	✓	✓	✓	✓	✓	✓	Recent and comprehensive survey undertaken	Have capacity for national stroke surveillance through registries
Slovak Republic	5.38	EHIS (2019)[115]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Slovenia	2.08	EHIS (2019)[115]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Solomon Islands	0.87	STEPS (2006)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Somalia	21.19	-	-	-	-	-	-	x		
South Africa	65.96	DHS (2016)[198]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Spain	46.65	EHIS (2019)[115]	✓	x	x	✓	✓	✓	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide
Sri Lanka	22.69	DHS (2016)[199]	✓	x	x	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Sudan	55.25	STEPS (2016)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Suriname	0.63	STEPS (2013)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Sweden	10.85	National Population Health Survey (NPHS; 2021); EHIS (2019)[115]	✓	x	x	✓	✓	✓	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide

Switzerland	9.14	SHARE (Wave 8; 2019-2020);[141] NHS (2017)[200]	✓	x	x	✓	✓	✓	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide
Syrian Arab Republic	26.68	STEPS (2013)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Taiwan	24.01	Nutrition and Health Survey in Taiwan (NAHSIT; 2017)[201]	✓	✓	✓	✓	✓	✓	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries could be expanded nationwide
Tajikistan	11.56	DHS (2017)[202]	x	✓	x	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Thailand	70.35	National Health Examination Survey (NHES V; 2014)[203]	✓	✓	✓	✓	✓	✓	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries could be expanded nationwide
Togo	10.42	DHS (2013-14)[204]	x	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Tonga	0.12	STEPS (2012)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Trinidad and Tobago	1.41	STEPS (2011)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Tunisia	12.76	DHS (1988)[205]	x	x	x	x	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Turkey	89.16	EHIS (2019)[115]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Turkmenistan	6.78	STEPS (2018)[114]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
Turks and Caicos Islands	0.04	-	-	-	-	-	-	x	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Tuvalu	0.01	STEPS (2015)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
USA	348.08	National Health Interview Survey (NHIS; 2021)[206]	✓	✓	✓	✓	✓	✓	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries could be expanded nationwide
Uganda	59.44	DHS (2016)[206]	✓	x	x	x	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Ukraine	41.19	STEPS (2019)[114]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
United Arab Emirates	10.66	STEPS (2017-2018)[114]	✓	✓	✓	✓	✓	x	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries required
United Kingdom, England and Wales	61.80	Health Survey for England (HSE; 2021)[207]	✓	✓	✓	✓	✓	✓	Recent and comprehensive survey undertaken	National capacity for stroke surveillance through registries could be expanded nationwide
United Kingdom, Northern Ireland	5.50	NHS (2020/21)[208]	x	x	x	✓	x	✓	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide

United Kingdom, Scotland	1.90	The Scottish Health Survey (2020)[209]	x	x	x	✓	✓	✓	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries could be expanded nationwide
United Republic of Tanzania	79.16	STEPS (2012)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Uruguay	3.57	Continuous Household Survey (2016)[210]	x	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Uzbekistan	38.51	STEPS (2014)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Vanuatu	0.38	STEPS (2011)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Venezuela	33.63	-	-	-	-	-	-	X	No information on risk factor survey found	National capacity for stroke surveillance through registries required
Vietnam	104.16	STEPS (2015)[114]	✓	✓	✓	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Virgin Islands (USA)	0.10	BRFSS (2021)[189]	x	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Yemen	36.41	DHS (2013)[211]	x	x	x	✓	✓	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required
Zambia	24.33	DHS (2018)[212]	✓	x	x	✓	✓	x	Recent survey undertaken, but lacking BP and biochemical measures	National capacity for stroke surveillance through registries required
Zimbabwe	17.60	DHS (2015)[213]	✓	x	x	✓	x	x	More comprehensive and/or recent survey required	National capacity for stroke surveillance through registries required

CAMDI, The Central American Diabetes Initiative; Nat Stroke Registry, National Stroke Registry; EHIS, European Health Interview Survey; EHES, European Health Examination Survey; DHS, Demographic Health Surveys; SHARE, Survey of Health, Ageing and Retirement in Europe; NHS, National Health Survey

[a] Projected population (per million) in the year 2030; [b] Some countries may have more recent surveys that are not listed in these online sources; [c] Data on the presence of national stroke registries were obtained from online resources; [d] Estimated unmet needs are based on the information obtained from online resources.

Supplementary Table 7: Thematic analysis of surveillance services - summary of barriers and facilitators to high performing stroke surveillance systems

	Barriers	Facilitators	Recommendations
Service provision	Concerns about accuracy of data on surveillance of stroke and risk factors Lack of detail or coverage on surveillance of stroke and risk factors Information restricted to individual or a small number of hospitals not representative of country No funding of collection or analysis of data Lack of regular data collection on stroke or its risk factors	Inclusion of health conditions (e.g., stroke) or health behaviours in regular national census collections Government responsibility for regular collection of data on stroke with input from experts National databases covering stroke care and outcomes Valid and reliable data on stroke and its risk factors collected by trained data collectors	Governments should be lobbied to include health conditions and/or behaviours in census National stroke plans should include action on surveillance of stroke and risk factors Methods and training to ensure precision of data on stroke and risk factors should be developed
Workforce	Lack of incentive for health professionals or support staff to collect data on stroke Limited training opportunities to build capacity in collection of data on stroke No dedicated funding for staff to collect or analyse data on stroke	Staff are motivated and have capacity to collect data on stroke and/or risk factors Government has invested in training of people to collect data on stroke and/or risk factors Staff have expertise to undertake research using data on stroke and/or risk factors	Identify sustainable sources of funding for collection of data on stroke and/or risk factors Create training opportunities leveraging existing resources to build capacity in collection of high-quality data on stroke and/or risk factors
Information system	Data collected on stroke and/or risk factors are not used for decision making within health systems or governments Limited capacity for data linkage using multiple sources of electronic information on stroke Data only collected on limited aspects of acute care and short-term outcomes	Wide range of data are collected in electronic formats that can be used for several purposes at a national level Systems and governance are in place for data linkage Web-based platforms are used to collect data on stroke and/or risk factors	Build capacity and funding for electronic medical records systems Develop strategies and governance for national data linkage systems
Technology and supplies	Investment in technology for data collection/analysis not a priority for government/health services No national strategy for electronic data collection on stroke and/or risk factors	Investment in IT systems to support electronic data collections including in health systems Web-based platforms for data collection on stroke are used within and across health systems	Promotion of existing web-based platforms for collection of data on stroke and/or risk factors
Finance	Funding of data collection on stroke and/or risk factors not a priority for governments Political instability affects funding across entire countries	Stroke organizations including health professionals and experts can support funding requests Governments (federal/state/regional) fund collection of data on stroke and its risk factors	National stroke organizations should demonstrate how data on stroke can be used to improve prevention, care and outcomes

Governance	No national plan for stroke surveillance including risk factors, care and outcomes Data that are available are not used nationally for decision making	National plans for stroke articulate stroke surveillance activities Adequate national funding allows good coverage of data and reporting Clear research ethics and governance procedures for collection, analysis and reporting of data	National stroke plans should include stroke surveillance as a key function

Supplementary Table 8: Key recommendations for improving stroke surveillance

Key recommendations	**Source**	**Resources required**	**implications /Barriers/Facilitators, for LMICs**	**Recommendation for contextualization and implementation through implemntation ecosytem on Stroke**
Countries should have a nationwide and representative system for monitoring stroke.	WHO – Global Action Plan on Epilepsy and other Neurological Disorders, target 4.1	Expertise in epidemiology, data management and statistics to support ongoing monitoring of stroke.[214]	Major barriers include lack of: (i) infrastructure to support a monitoring program (ii) expertise to develop an efficient program (iii) capacity to analyse the data collected and produce quality statistics (iv) community engagement and feedback of data to enhance demand and accountability; and (v) use of data to drive decision-making. (vi) need for standardized and validated indicators of stroke burden from linked datasets	WSO IMplementation Ecosystem on stroke to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of a high-quality monitoring of stroke in their countries and regions. This should include a stepped approach that highlights the elements required for minimum (hospitalized events), essential and advanced monitoring, i.e. incorporating the WHO stepwise approach, or similar.
Countries should have a nationwide monitoring program of risk factors for stroke.	WHO - Global Action Plan on Epilepsy and other Neurological Disorders, strategic objective 3, proposed action	Expertise in epidemiology, data management and statistics to support a regular cycle of national	Major barriers include lack of: a) Infrastructure to support a surveillance program. b) expertise to develop an efficient program c) capacity to analyse the data collected and produce quality statistics. d) community engagement and feedback of data to enhance demand and accountability; and	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of a high-quality surveillance system in their countries and regions. This should include a stepped approach that highlights the elements required for minimum, essential and advanced surveillance, i.e. incorporating the WHO stepwise approach, or similar.

	88b; NCD-GAP; 2030 Agenda	surveys and analysis.[214]	e) use of data to drive decision-making.	
Countries should have an electronic recording and reporting system for health care.	WHO – Global Strategy on Digital Health 2020-25; Global Action Plan on Epilepsy and other Neurological Disorders, strategic objective 4.2 Data and information systems	Expertise in development and maintenance of secure online data to support rapid and simple input of patient-relevant data.	Major barriers include lack of: (i) infrastructure to support an electronic data system (ii) expertise to develop and maintain a secure record-keeping system (iii) expertise to link data to other collection systems, e.g., death records, to enable assessment of outcomes; and (iv) need for expertise in clinical coding including use of WHO ICD system (v) develop tools to increase quality and coverage of mortality data including verbal autopsy	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of a secure data record system in their countries and regions. This could include the employment of Community Health Workers to register people in the community; this would include a capacity-building component to train them in use of technology, transport to enable collection of information, and appropriate remuneration.
Countries should establish national stroke organizations to guide and advocate for surveillance of stroke including burden, management, and outcomes	WHO – Global Strategy on Digital Health 2020-25; Global Action Plan on Epilepsy and other Neurological Disorders, global targets 1.1 and 1.2	Expertise in governance, co-design, interdisciplinary ways of working, consumer, and government engagement	Major barriers include lack of: a) resources including cash and in-kind time to establish national networks of researchers and clinicians b) funding to prepare national policy documents including stakeholder engagement; and c) need for mentoring for leaders of new organizations	WSO implementation ecosystem on Stroke commissioners to develop national stroke organizations including mentoring and capacity building for health professionals and clinicians. This should include mechanisms to report to governments to enact meaningful and sustainable change.

Supplementary Table 9: Estimated coverage and unmet needs for prevention, according to country

Country Name	Population 2018	Population 2019	Projected Population 2030	Primary	Secondary	Overall	No. of hospitals	Complete items*	Estimated Unmet Needs*
Albania	2866376	2867000	2830000	50.0	60.0	55.0	1	9	Need to further advance implementation of strategies for primary and secondary stroke prevention
Argentina	44494502	44901000	49069000	16.7	20.0	18.3	3	2	Need to develop and implement strategies for primary and secondary stroke prevention
Armenia	2951776	2958000	2967000	30.0	250	4.0	4	3	Need to develop and implement strategies for primary and secondary stroke prevention
Aruba	105845	106000	110000	0.0	0.0	0.0	1	2	Need to develop and implement strategies for primary and secondary stroke prevention
Australia	24992369	25303000	28393000	25.0	36.3	30.6	8	3.5	Need to further advance implementation of strategies for primary and secondary stroke prevention
Austria	8847037	8865000	9017000	50.0	50.0	50.0	2	8	Need to further advance implementation of strategies for primary stroke prevention
Bangladesh	161356039	163046000	178994000	0.0	5.0	2.5	2	2.5	Need to develop and implement strategies for primary and secondary stroke prevention
Belarus	9485386	9467000	9191000	0.0	30.0	15.0	1	8	Need to develop and implement strategies for primary stroke prevention and further advance implementation of strategies for secondary stroke prevention
Belgium	11422068	11483000	11904000	37.5	55.0	46.3	4	8	Need to further advance implementation of strategies for primary and secondary stroke prevention
Benin	11485048	11801000	15672000	0.0	30.0	15.0	1	10	Need to develop and implement strategies for primary stroke prevention and further advance implementation of strategies for secondary stroke prevention

Bolivia	11353142	11513000	13240000	50.0	50.0	50.0	1	7	Need to further advance implementation of strategies for primary and secondary stroke prevention
Brazil	209469333	211050000	223852000	22.9	26.3	24.6	24	3	Need to further advance implementation of strategies for primary and secondary stroke prevention
Bulgaria	7024216	6970000	6338000	50.0	70.0	60.0	2	9.5	Need to further advance implementation of strategies for primary and secondary stroke prevention
Burkina Faso	19751535	20321000	27404000	0.0	0.0	0.0	1	2	Need to develop and implement strategies for primary and secondary stroke prevention
Cameroon	25216237	25876000	33766000	0.0	50.0	25.0	1	7	Need to develop and implement strategies for primary stroke prevention and further advance implementation of strategies for secondary stroke prevention
Canada	37058856	37375000	40352000	50.0	10.0	30.0	1	3	Need to further advance implementation of strategies for primary and secondary stroke prevention
Chile	18729160	18952000	19458000	50.0	83.3	66.7	3	13	Need to further advance implementation of strategies for primary and secondary stroke prevention
China	1392730000	1397295000	1416292000	40.0	30.0	35.0	5	5	Need to further advance implementation of strategies for primary and secondary stroke prevention
Colombia	49648685	50339000	53417000	62.5	72.5	67.5	4	13.5	Need to further advance implementation of strategies for primary and secondary stroke prevention
Congo, Dem. Rep.	84068091	86791000	120047000	0.0	0.0	0.0	1	6	Need to develop and implement strategies for primary and secondary stroke prevention
Costa Rica	4999441	5048000	5468000	33.3	36.7	35.0	3	11	Need to further advance implementation of strategies for primary and secondary stroke prevention
Croatia	4089400	4071000	3864000	50.0	65.5	57.7	11	11	Need to further advance implementation of strategies for primary and secondary stroke prevention

Czech Republic	10625695	10629000	10491000	0.0	50.0	25.0	2	7.5	Need to develop and implement strategies for primary stroke prevention and further advance implementation of strategies for secondary stroke prevention
Denmark	5797446	5818000	6047000	50.0	65.0	57.5	2	9	Need to further advance implementation of strategies for primary and secondary stroke prevention
Egypt, Arab Rep.	98423595	100388000	120832000	16.7	46.7	31.7	3	11	Need to further advance implementation of strategies for primary and secondary stroke prevention
Estonia	1320884	1317000	1265000	0.0	80.0	40.0	1	14	Need to develop and implement strategies for primary stroke prevention and further advance implementation of strategies for secondary stroke prevention
Ethiopia	109224559	112079000	144944000	20.0	38.0	29.0	5	9	Need to further advance implementation of strategies for primary and secondary stroke prevention
France	66987244	67211000	69509000	30.0	34.0	32.0	5	11	Need to further advance implementation of strategies for primary and secondary stroke prevention
Georgia	3731000	3721000	3562000	50.0	100.0	75.0	1	17	Need to further advance implementation of strategies for primary stroke prevention
Germany	82927922	82806000	81520000	50.0	52.5	51.3	4	7	Need to further advance implementation of strategies for primary and secondary stroke prevention
Ghana	29767108	30418000	37833000	75.0	55.0	65.0	2	14	Need to further advance implementation of strategies for primary and secondary stroke prevention
Greece	10727668	10696000	10355000	50.0	80.0	65.0	1	17	Need to further advance implementation of strategies for primary and secondary stroke prevention
Honduras	9587522	9746000	11449000	50.0	100.0	75.0	1	17	Need to further advance implementation of strategies for primary stroke prevention

Hong Kong	7451000	7508000	8024000	50.0	50.0	50.0	1	8	Need to further advance implementation of strategies for primary and secondary stroke prevention
Hungary	9768785	9732000	9292000	50.0	50.0	50.0	1	10	Need to further advance implementation of strategies for primary and secondary stroke prevention
India	1352617328	1366418000	1503642000	46.9	45.0	45.9	16	9	Need to further advance implementation of strategies for primary and secondary stroke prevention
Iran, Islamic Rep.	81800269	82914000	92664000	50.0	80.0	65.0	1	17	Need to further advance implementation of strategies for primary and secondary stroke prevention
Ireland	4853506	4893000	5255000	50.0	50.0	50.0	1	7	Need to further advance implementation of strategies for primary and secondary stroke prevention
Israel	8883800	9018000	10471000	50.0	90.0	70.0	1	16	Need to further advance implementation of strategies for primary and secondary stroke prevention
Italy	60431283	60340000	59196000	37.5	70.0	53.8	4	14	Need to further advance implementation of strategies for primary and secondary stroke prevention
Japan	126529100	126097000	120095000	0.0	5.0	2.5	2	2	Need to develop and implement strategies for primary and secondary stroke prevention
Kazakhstan	18276499	18469000	20165000	35.0	45.0	40.0	10	11	Need to further advance implementation of strategies for primary and secondary stroke prevention
Kenya	51393010	52574000	66450000	0.0	10.0	5.0	1	2	Need to further advance implementation of strategies for primary and secondary stroke prevention
Korea, Rep.	51635256	51782000	52975000	33.3	67.8	50.6	9	13	Need to further advance implementation of strategies for primary and secondary stroke prevention
Kyrgyz Republic	6315800	6404000	7218000	100.0	90.0	95.0	1	17	Need to further advance implementation of strategies for secondary stroke prevention

Latvia	1926542	1916000	1796000	50.0	62.5	56.3	4	13.5	Need to further advance implementation of strategies for primary and secondary stroke prevention
Lebanon	6848925	6856000	6195000	0.0	10.0	5.0	1	2	Need to further advance implementation of strategies for primary and secondary stroke prevention
Malaysia	31528585	31950000	36095000	43.8	42.5	43.1	8	6	Need to further advance implementation of strategies for primary and secondary stroke prevention
Mexico	126190788	127576000	140876000	25.0	75.0	50.0	2	12	Need to further advance implementation of strategies for primary and secondary stroke prevention
Moldova	3545883	3536000	3368000	37.5	61.3	49.4	8	13	Need to further advance implementation of strategies for primary and secondary stroke prevention
Morocco	36029138	36472000	40887000	50.0	33.3	41.7	3	11	Need to further advance implementation of strategies for primary and secondary stroke prevention
Nepal	28087871	28609000	33390000	31.3	52.5	41.9	8	9.5	Need to further advance implementation of strategies for primary and secondary stroke prevention
New Zealand	4885500	4929000	5342000	66.7	66.7	66.7	3	7	Need to further advance implementation of strategies for primary and secondary stroke prevention
Nigeria	195874740	200964000	262977000	16.7	25.0	20.8	6	6.5	Need to further advance implementation of strategies for primary and secondary stroke prevention
North Macedonia	2082958	2083000	2051000	50.0	50.0	50.0	1	11	Need to further advance implementation of strategies for primary and secondary stroke prevention
Norway	5314336	5369000	5854000	50.0	50.0	50.0	3	6	Need to further advance implementation of strategies for primary and secondary stroke prevention

Pakistan	212215030	216565000	262959000	0.0	40.0	20.0	1	7	to develop and implement strategies for primary stroke prevention and further advance implementation of strategies for secondary stroke prevention
Panama	4176873	4246000	4928000	0.0	90.0	45.0	1	11	Need to develop and implement strategies for primary stroke prevention and further advance implementation of strategies for secondary stroke prevention
Papua New Guinea	8606316	8776000	10709000	0.0	0.0	0.0	1	3	Need to develop and implement strategies for primary stroke prevention and secondary stroke prevention
Paraguay	6956071	7045000	7950000	50.0	10.0	30.0	1	3	Need to further advance implementation of strategies for primary and secondary stroke prevention
Peru	31989256	32510000	36031000	0.0	25.0	12.5	2	9.5	Need to develop and implement strategies for primary stroke prevention and further advance implementation of strategies for secondary stroke prevention
Poland	37978548	37895000	36474000	25.0	85.0	55.0	2	13.5	Need to further advance implementation of strategies for primary and secondary stroke prevention
Portugal	10281762	10237000	9832000	38.9	32.2	35.6	9	5	Need to further advance implementation of strategies for primary and secondary stroke prevention
Russian Federation	144478050	144369000	140912000	50.0	70.0	60.0	2	12.5	Need to further advance implementation of strategies for primary and secondary stroke prevention
Rwanda	12301939	12627000	16234000	50.0	10.0	30.0	1	4	Need to further advance implementation of strategies for primary and secondary stroke prevention
Serbia	6982084	6955000	6625000	25.0	61.7	43.3	6	11	Need to further advance implementation of strategies for primary and secondary stroke prevention

Seychelles	96762	97000	99000	0.0	25.0	12.5	2	6.5	Need to develop and implement strategies for primary stroke prevention and further advance implementation of strategies for secondary stroke prevention
Singapore	5638676	5710000	6157000	40.0	36.0	38.0	5	3	Need to further advance implementation of strategies for primary and secondary stroke prevention
Slovak Republic	5447011	5448000	5377000	16.7	36.7	26.7	3	2	Need to further advance implementation of strategies for primary and secondary stroke prevention
South Africa	57779622	58558000	65956000	37.5	47.5	42.5	3	9	Need to further advance implementation of strategies for primary and secondary stroke prevention
Sri Lanka	21670000	21757000	22234000	0.0	12.5	6.3	4	2.5	Need to develop and implement strategies for primary stroke prevention and further advance implementation of strategies for secondary stroke prevention
Sudan	41801533	42813000	55254000	50.0	30.0	40.0	2	7	Need to further advance implementation of strategies for primary and secondary stroke prevention
Sweden	10183175	10251000	10933000	37.5	32.5	35.0	4	2.5	Need to further advance implementation of strategies for primary and secondary stroke prevention
Taiwan	23726460	23773876	24011258	66.7	58.3	62.5	6	9	Need to further advance implementation of strategies for primary and secondary stroke prevention
Thailand	69428524	69626000	70346000	66.7	96.7	81.7	3	16	Need to further advance implementation of strategies for primary and secondary stroke prevention
Turkey	82319724	83430000	89158000	43.8	51.9	47.8	16	9	Need to further advance implementation of strategies for primary and secondary stroke prevention
Uganda	42723139	44270000	59438000	0.0	40.0	20.0	1	7	Need to develop and implement strategies for primary stroke prevention and further advance

									implementation of strategies for secondary stroke prevention
Ukraine	44622516	44391000	41719000	37.5	70.0	53.8	4	14	Need to further advance implementation of strategies for primary and secondary stroke prevention
United Arab Emirates	9630959	9771000	10661000	50.0	40.0	45.0	1	7	Need to further advance implementation of strategies for primary and secondary stroke prevention
United Kingdom	66488991	66856000	70277000	28.1	30.0	29.1	16	3	Need to further advance implementation of strategies for primary and secondary stroke prevention
United States	327167434	329534000	354448000	30.0	42.7	36.3	15	7	Need to further advance implementation of strategies for primary and secondary stroke prevention
Uruguay	3449299	3462000	3569000	50.0	80.0	65.0	1	17	Need to further advance implementation of strategies for primary and secondary stroke prevention
Vietnam	95540395	96462000	104164000	50.0	50.0	50.0	1	7	Need to further advance implementation of strategies for primary and secondary stroke prevention
Wales	3,139,308	3,151,569	3,234,289	0.0	10.0	5.0	1	2	Need to develop and implement strategies for primary stroke prevention and further advance implementation of strategies for secondary stroke prevention

* Refers to median number of questions answered (out of 17 possible questions) for each country.

Supplementary Table 10. Summary of barriers and facilitators to stroke prevention services

	Barriers	Facilitators	Recommendations
Service provision	Unequal distribution of services across the country	Wide network of service delivery (through GP or community health staff)	Establish a continuum of care for stroke prevention
	Low health literacy of the population regarding stroke prevention	Coordinated service delivery for primary and secondary stroke prevention	Improve population health literacy on stroke prevention
	Lack of continuum of stroke prevention services	Primary stroke prevention activities are led by the government	
Workforce	Lack of health staff	High capacity and motivation of staff	Provide training for health staff, especially primary health care and community health workers on stroke prevention.
	Lack of incentive for health staff to work in rural areas	Availability of training opportunity for health staff	Improve incentives for health staff in rural areas to encourage relocation and retention
	Lack of stroke-specific training for health staff		
Information system	Lack of adequate and systematic information	Data used for auditing and benchmarking	Identify key data to be collected at all facilities to contribute to national priority setting, monitoring and evaluation of stroke prevention
	Lack of data use for decision making	Availability of a national database	
Technology and supplies	Unavailability of medications	Advancement in information technology infrastructure	Essential drugs for secondary prevention should be subsidized by the government and made available at all hospitals.
	Inadequate infrastructure to implement new technologies	Use of social media for primary stroke prevention	Use social media to deliver stroke prevention communication and education
	Lack of access to new technologies		
Finance	Lack of funding	Adequate resources allocated for stroke prevention	Primary and secondary stroke prevention services should be covered by the national health insurance/universal health coverage
	Lack of universal health coverage or government-subsidized services	Universal health coverage	
		Government-subsidized or low fee prevention services	Government to set a fixed proportion of annual health funding for stroke prevention activities
Governance	Stroke prevention has low priority on government agenda	National policy to control risk factors for cardiovascular diseases or stroke	Develop/update national strategy on cardiovascular diseases/stroke prevention
	Lack of national strategy for cardiovascular diseases and/or stroke prevention. Lack of clear stroke prevention guidelines	Availability of clear guidelines for stroke prevention. Participation of stroke organisztion in advocacy and policy development in stroke prevention	Develop/update national guidelines for stroke prevention.
			Enhance the involvement of stroke organizations in advocacy and policy development in stroke prevention

Supplementary Table 11: Key recommendations for healthcare providers and governments to improve primordial, primary and secondary stroke prevention

Key recommendations	Source	Level of evidence/ GRADE[4]	Resources required for implementation	Political, legal, ethical, sociocultural and economic considerations for barriers and facilitators	Recommendation for implementation through WSO implementation ecosystem on Stroke
Countries should have government endorsed policies for community-wide stroke prevention.	UN/WHO[215] Action plan for stroke in Europe,[11] AHA Guide for improving cardiovascular health at the community level[216]	Level B evidence that tobacco,[214,217,218] salt[219,220] and alcohol[9–13221-225] taxation is an effective strategy to improve health. Level A evidence for population-wide primary stroke and other NCD prevention[14–16226-228]	Expertise in stroke and CVD epidemiology and public health	Major barriers: Industry lobbying (e.g., for reducing salt content in processed food, reducing consumption of sugary drinks, alcohol) as well as lack of: a) expertise to develop an efficient action plan b) community support for introducing taxation on salt, sugary drinks, alcohol, tobacco products c) government and health policy engagement; and d) public resources for accessible and affordable healthy food outlets, physical activity facilities, healthy ecological environment	WSO implementation ecosystem on Stroke commissioners to develop legislative changes for reducing salt content in processed food, reducing consumption of sugary drinks, alcohol, including development of policies for community-wide stroke prevention activities, monitoring effectiveness of these activities, and workforce development. Reinvestment of taxation revenue into primary (including the development of accessible and affordable healthy food outlets, physical activity facilities, reducing air pollution) and secondary prevention, health service development and health research.
Countries should have ongoing stroke awareness and prevention campaigns and interventions. The main risk factors to be targeted for primary stroke prevention are: elevated blood pressure (≥120/80), low physical activity (<2½ hours a week of moderate to vigorous exercise), poor unbalanced diet (e.g. less than 6 servings a day of fruits or vegetables), excessive sodium (>2 g/day; equivalent to 5 g/salt/day) intake, overweight (BMI ≥25 or waist-to-hip ratio ≥0.8 for women and ≥0.9 for men), tobacco use, cardiac causes (coronary heart disease, atrial fibrillation (AF), valve disease, heart failure), dyslipidaemia (total cholesterol ≥5 mmol/L or 200 mg/dL;	WSO,[109] WHO[238], Action plan for stroke in Europe,[11] Gramado Declaration[32] AHA stroke primary and secondary prevention guidelines,[234,237,239]	Level B evidence.[226-228] WHO 'One Health' initiative[238] Level A evidence for risk factors control for stroke prevention[24,29,30234,239,246]	Expertise in development and maintenance of awareness campaigns; electronic patient management systems.	Major barriers include lack of: (vi) engagement of stakeholders (patients, populace, providers, and policy makers) (vii) collaboration between multiple sectors of society (e.g., government, public health, research/education)	WSO implementation ecosystem on Stroke commissioners to develop strategies and action plans for ongoing stroke awareness and primary prevention, with a strong emphasis in LMICs on early detection and management of elevated BP, and on reduction of exposure to air pollution. They should develop a plan for

LDL-C ≥4 mmol/L or ≥150 mg/dL; HDL-C <1 mmol/L or <40 mg/dL; triglycerides >1.7 mmol/L or 150/mg/dL), persistent stress or depression, alcohol consumption (>1 standard drink a day), and diabetes mellitus. Primary stroke prevention is cost-effective: investing US$1.27 per person per year in LMICs until 2030 can save an estimated 8.2 million lives and yield a return on investment of at least US$7.[229,230] Non-pharmacological and motivational cognitive-behavioural interventions are recommended for lifestyle risk management. For example, regular physical activity before the index event was found to be associated with reduced risk of poor functional outcome after stroke (OR 0·52, 95% CI 0·42–0·66; p<0·0001).

For primary stroke and CVD prevention, polypill containing generic BP-lowering medications and statin can be recommended in adults at intermediate (10-20% 10-year Framingham Risk Score) or greater CVD risk,[231] and no contraindications to the medications. Individuals aged 40-75 years with isolated hypercholesterolaemia of LDL-C ≥4.9 mmol/L (≥190 mg/dL) should receive high-intensity statin therapy without calculating CVD risk. Individuals of that age group with LDL-C levels ≥70 mg/dL to 189 mg/dL (≥1.8-4.9 mmol/L) should receive statin therapy if their 10-year CVD risk is 7.5-19.9% (if a decision about statin therapy is uncertain, a clinician should consider measuring coronary artery calcium)**.**[232] Aspirin should not be routinely used for primary stroke prevention, but is recommended for secondary stroke prevention after TIA or ischaemic stroke. Pharmacological treatment of elevated blood pressure for primary stroke prevention should be initiated in (a) people with SBP ≥140 mmHg or DBP ≥90 mmHg, or (b) people with existing CVD and SBP 130-139 mmHg, or (c) people with SBP 130-139 mmHg but without CVD who are at high CVD risk (10-year Framingham Risk Score >20%), diabetes mellitus, or chronic kidney disease.[233] The use of BP-lowering medications for secondary stroke prevention in people with clinical CVD should be initiated with BP ≥130/80 mmHg.[234,235] Most individuals with SBP ≥140 or DBP ≥90 mmHg are high risk and indicated for pharmacological treatment; they do not require CVD risk assessment prior to initiating treatment.

Secondary stroke prevention interventions have been shown to be cost-effective.[236] For secondary stroke prevention, control of hypertension, blood glucose, and lipids (regardless of their level) as well as timely diagnostic evaluation are effective.[234] For those

WHO Guidelines,[233] INTERSTROKE Study,[240] GBD Study,[241] Framingham Study,[242,243] White Paper for Circulatory Health,[244] European Guidelines on CVD prevention.[245]

Level A evidence for use of polypill[231,247,248] for BP and cholesterol reduction.[232,234,235] Level A evidence for use of antiplatelet therapy, oral anticoagulation, blood pressure and lipid lowering therapy, and carotid revascularization for secondary stroke prevention.[232,249-261] Level of evidence for lifestyle modifications for secondary stroke prevention: smoking cessation and healthy balanced diet (B),[262-264] limited alcohol consumption and sodium intake, regular physical activity, normal BMI (C),[31,54,55240,264,265] and salt substitute (A).[266]

prioritization of multisectoral and cost-effective accessible and affordable interventions, including Implementation of and digital technologies for promoting healthy lifestyle[267-270] and primary /secondary stroke prevention.[28,61–65][1,32,101,111,112,268,271,272] For example, population-wide strategies recently recommended for implementation for stroke prevention in all Latin American countries (e.g. the free Stroke Riskometer app),[32] should be one of the priorities for funders and policy makers.[32,271] A sustained TV-led FAST education campaign led to significant improvement of stroke awareness and timely hospital admissions in the UK.[273] There is evidence that multidomain lifestyle intervention is effective for primary and secondary stroke prevention.[274] Legislative changes in South Africa led to the reduction of salt consumption.[275] Evidence-based digital tools (e.g. the PreventS-MD webapp)[112,272] and most recent ASA/AHA guidelines for secondary stroke prevention recommend them in patients with stroke and TIA[111,234,276] for use and adaptation for local conditions, when required.

requiring pharmacological therapy, the target blood pressure should generally be <130/80 mm Hg.[234,235,237]					
Countries should have a nationwide and representative system for measuring and monitoring effects of primary and secondary stroke prevention activities (for more details see surveillance section). This should include a stepped approach that highlights the elements required for minimum (hospitalized events), essential and advanced monitoring, i.e. incorporating the WHO stepwise approach[277] or similar.[278-280] In patients with nonvalvular AF (including paroxysmal) or atrial flutter and stroke or TIA, oral anticoagulation is recommended.[234] Ischaemic stroke patients with severe stenosis ipsilateral to a nondisabling stroke or TIA who are candidates for intervention should have the stenosis fixed, likely relatively early after their ischemic stroke.[234] The choice between carotid endarterectomy and carotid artery stenting should be driven by specific patient comorbidities and features of their vascular anatomy.[234] Large health service providers should have outpatient Stroke Clinics to facilitate GPs in better management of post-discharge stroke/TIA patients. In LMICs with high rate of rheumatic heart disease Oral Anticoagulation Clinics are also recommended.	WHO STEPs,[277] Action plan for stroke in Europe[11]	Level B evidence	Expertise in epidemiology, data management and statistics to support ongoing monitoring of stroke.	Major barriers include lack of: (vii) infrastructure to support a monitoring program (viii) expertise to develop an efficient program (ix) capacity to analyse the data collected and produce quality statistics (x) use of data to drive decision-making.	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor reliable, simple, and fit-for-purpose strategic action plan with all stakeholders to ensure availability of a reliable monitoring of stroke and risk factors standardized surveillance systems in their countries and regions.

Supplementary Table 12: Identified problems with and suggested strategies for policy makers to achieve sustainable and appropriate primary and secondary stroke prevention

Problems	Goals	Targets	Recommendations/Actions	Assessment methods
Lack of funding for primary stroke prevention across all countries, particularly in LMICs	To provide sufficient funding for primary and secondary stroke prevention	Governments and politicians	Encourage all governments and politicians to re-invest revenues from taxation on unhealthy products (e.g., tobacco, sugary drinks, alcohol, salt in processed food, reduced consumption) back to health services and preventative strategies All healthcare policy makers should be aware that for every US$1 spent on prevention of stroke and CVD there are over US$10 returns on investment	Proportion of funding allocated to primary and secondary stroke prevention
Few countries or regions have established action plans for stroke prevention. Low level of secondary prevention activities, especially in LMICs and activities related to education about stroke and lifestyle management for stroke patients and their families, stroke/TIA clinics and guidelines utilization	To establish country-specific action plans and stroke prevention guidelines for every country in the world	The whole population for population-wide prevention strategies and individuals at any level of risk for individual prevention strategies	All governments should allocate sufficient funding for the development and implementation of primary stroke prevention strategies All countries should have financially sustainable action plans for primary and secondary stroke prevention All countries should have culturally appropriate guidelines for primary and secondary stroke prevention Adults are encouraged to use the freely available and validated mobile apps for managing their risk factors (e.g., the WSO recommended free Stroke Riskometer app) Upskilling of health staff, including doctors, nurses, and other support staff, in the primary and secondary prevention of stroke, including providing advice on lifestyle changes and adherence to medications Transferring tasks of primary stroke prevention from highly trained health professionals to healthcare workers with less training, qualifications, and education should be encouraged Culturally appropriate education about healthy lifestyles should be incorporated into standard education curricula and started early in life, with reinforcement across the lifespan Service providers should ensure adequate health services for people with acute cerebrovascular diseases to reduce the risk of recurrent stroke, including multidisciplinary acute stroke units, outpatient stroke/TIA clinics and routinely available education about stroke and lifestyle management for stroke patients and their families, ongoing stroke and risk factors awareness campaigns, and availability of valid digital secondary stroke prevention tools for clinicians	Stroke incidence, mortality, and disability Prevalence of risk factors 5 or 10-year risk of CVD and/or stroke Availability of stroke/TIA and stroke prevention clinics and proportion of people at risk of stroke and people who have experienced a stroke or TIA managed in such clinics Proportion of evidence-based decisions in stroke prevention
Lack of integrative approach and digital tools for primary and secondary stroke prevention interventions, particularly in LMICs	To establish collaboration between different national and international agencies and organizations involved in primary and secondary prevention of NCDs	National and international agencies and organizations	Include nationally and internationally recognized stroke experts in all relevant national and international agencies and organizations involved in primary and secondary prevention of NCDs Priority in the primary stroke prevention strategies should be given to the reduction of exposure to CVD risk factors of the whole population across the life course, with the focus on behavioural and lifestyle risk factors, thus allowing an integrative approach that also targets other major NCDs, such as dementia, diabetes, cancer, and pulmonary diseases. Absolute CVD risk treatment thresholds should not be the sole criteria for selecting individuals for pharmacological management of elevated blood pressure and lipids. Categorization of people into low, moderate (mild) and high absolute CVD risk (including use of risk-stratified heat maps)	Representation of stroke experts in all relevant national and international agencies and organizations involved in primary prevention of NCDs

			when communicating risk should be abandoned, and individual primary stroke and CVD prevention interventions should include all people at increased risk of stroke and CVD regardless of the level of the increased risk. All countries should be encouraged to adapt validated, affordable, and culturally appropriate digital tools for secondary stroke prevention.	
Low stroke awareness across all countries	To establish national ongoing stroke awareness campaigns about stroke, its warning signs and prevention	The whole population	All national and regional stroke organizations should conduct ongoing stroke awareness campaigns about stroke, its warning signs and prevention, coordinated by the World Stroke Organization. Regular TV programmes are the preferred channel of media for such campaigns	Stroke awareness surveys
Lack of monitoring systems for evaluation of the effectiveness of preventative strategies	To establish national and subnational (for large countries) monitoring frameworks	Whole population and people at risk of stroke	All countries should have monitoring systems to evaluate the effects of primary and secondary prevention strategies In the absence of sufficient quality country-specific epidemiological data on stroke burden and risk factors, healthcare policy makers should be encouraged to use relevant Global Burden of Disease estimates Regular use of accurate data to support decision-making	Changes in the 5- or 10-year absolute risk of stroke/CVD of outpatients Registries of recurrent strokes/TIA (including their outcomes), digital tools for monitoring trends in stroke/CVD risk and risk factors
Insufficient funding of stroke prevention research across all countries, particularly in LMICs	To study determinants of stroke occurrence and outcomes and the best strategies to reduce stroke burden	Health research funding agencies	In consultation with recognized regional experts on stroke and public health, allocate sufficient funding for research in primary and secondary stroke prevention	Proportion of research funding allocated to primary stroke prevention (compared to the total health research funding)
Affordability of essential drugs for primary and secondary stroke prevention across all countries	To establish a list of essential drugs for primary and secondary stroke	People at risk of stroke	All countries should have a list of essential drugs for primary and secondary stroke prevention funded by the government	Availability of government subsidized essential drugs for primary and secondary stroke prevention aligned with the WHO list of essential drugs

Supplementary Table 13: Estimated coverage and unmet needs for acute care according to country

Country Name	Population 2018	Population 2019	Projected Population 2030	Estimated Coverage for Acute care					Estimated Unmet Needs*
				Section Score	Guidelines Protocols	Acute Treatments	Acute Stroke Unit	General acute care	
Albania	2866376	2867000	2830000	70.3	0.0	100.0	100.0	44.4	Only 1 hospital represented in the survey, need to follow guidelines and implement protocols
Argentina	44494502	44901000	49069000	47.2	40.0	58.3	100.0	63.0	Only 2 hospitals represented, the country needs to implement stroke centres, guidelines, protocol
Armenia	2951776	2958000	2967000	0.0	25.0	8.7	100.0	25.0	Need to implement stroke centres and acute care in the country
Aruba	105845	106000	110000	0.0	0.0	0.0	0.0	0.0	Need to implement stroke centres and acute care in the country
Australia	24992369	25303000	28393000	50.5	40.0	59.4	100.0	69.4	Need to improve acute treatments, same number of stroke units may still be adequate in 2030
Austria	8847037	8865000	9017000	42.6	40.0	50.0	100.0	72.2	Same number of stroke units may still be adequate in 2030
Bangladesh	161356039	163046000	178994000	10.5	0.0	0.0	50.0	44.4	Need to implement stroke centres and acute care in the country
Belarus	9485386	9467000	9191000	22.5	0.0	25.0	100.0	77.8	Only 1 hospital represented in the survey, need to follow guidelines, implement protocols and acute care in the country

Belgium	11422068	11483000	11904000	65.2	55.0	75.0	100.0	88.9	Same number of stroke centres/ stroke units may still be adequate in 2030
Benin	11485048	11801000	15672000	7.7	0.0	25.0	0.0	44.4	Need to implement stroke centres and acute care in the country
Bolivia	11353142	11513000	13240000	7.7	0.0	25.0	0.0	44.4	Need to implement stroke centres and acute care in the country
Brazil	209469333	211050000	223852000	30.9	17.5	29.2	58.3	75.5	Need to implement guidelines and protocols, need to improve access to acute treatments and increase the number of stroke centres in the country
Bulgaria	7024216	6970000	6338000	71.9	50.0	87.5	100.0	77.8	Same number of stroke centres/ stroke units may still be adequate in 2030
Burkina Faso	19751535	20321000	27404000	2.5	0.0	0.0	0.0	22.2	Need to implement stroke centres and acute care in the country
Cameroon	25216237	25876000	33766000	20.1	0.0	25.0	100.0	55.6	Only 1 hospital in the survey, need to implement protocols, stroke centres and acute care in the country
Canada	37058856	37375000	40352000	18.5	0.0	0.0	100.0	66.7	Only 1 hospital represented in the survey, same number of stroke centres/ stroke units may still be adequate in 2030
Chile	18729160	18952000	19458000	63.5	46.7	75.0	100.0	81.5	Same number of stroke centres/ stroke units may still be adequate in 2030
China	1392730000	1397295000	1416292000	53.6	52.0	75.0	100.0	77.8	Same number of stroke centres/ stroke units may still be adequate in 2030
Colombia	49648685	50339000	53417000	67.0	60.0	75.0	100.0	72.2	Only 3 hospitals represented, need to increase the number of stroke centres and to increase the implementation of acute stroke treatments
Congo, Dem. Rep.	84068091	86791000	120047000	8.9	0.0	0.0	0.0	22.2	Need to implement stroke centres and acute care in the country

Costa Rica	4999441	5048000	5468000	44.7	33.3	66.7	66.7	81.5	Need to increase the number of stroke centres and the implementation of acute stroke treatments
Croatia	4089400	4071000	3864000	60.7	60.0	75.0	100.0	75.8	Same number of stroke centres/ stroke units may still be adequate in 2030
Czech Republic	10625695	10629000	10491000	42.9	20.0	62.5	100.0	88.9	Same number of stroke centres/ stroke units may still be adequate in 2030
Denmark	5797446	5818000	6047000	79.9	80.0	100.0	100.0	94.4	Same number of stroke centres/ stroke units may still be adequate in 2030
Egypt, Arab Rep.	98423595	100388000	120832000	38.7	20.0	33.3	100.0	81.5	Same number of stroke centres/ stroke units may still be adequate in 2030
Estonia	1320884	1317000	1265000	74.6	80.0	100.0	100.0	77.8	Same number of stroke centres/ stroke units may still be adequate in 2030
Ethiopia	109224559	112079000	144944000	27.1	12.0	10.0	20.0	31.1	Need to implement stroke centres and acute care in the country
France	66987244	67211000	69509000	31.5	16.0	30.0	100.0	88.9	Need to implement guidelines and protocols, need to improve acute treatments and increase the number of stroke centres in the country
Georgia	3731000	3721000	3562000	73.5	60.0	100.0	100.0	33.3	Only 1 hospital represented, need to implement basic acute stroke care
Germany	82927922	82806000	81520000	48.2	40.0	56.3	100.0	88.9	Same number of stroke centres/ stroke units may still be adequate in 2030
Ghana	29767108	30418000	37833000	48.3	40.0	25.0	50.0	33.3	Need to implement stroke centres and acute care in the country
Greece	10727668	10696000	10355000	73.1	60.0	100.0	100.0	55.6	Same number of stroke centres/ stroke units may still be adequate in 2030
Honduras	9587522	9746000	11449000	81.3	40.0	100.0	100.0	77.8	Only 1 hospital represented in the survey, need to follow guidelines, implement protocols and the country needs to implement stroke centres and acute care in the country

Hong Kong	7451000	7508000	8024000	86.4	100.0	75.0	100.0	100.0	Same number of strokes centres/ stroke units may still be adequate in 2030
Hungary	9768785	9732000	9292000	63.7	60.0	100.0	100.0	66.7	Same number of stroke centres/ stroke units may still be adequate in 2030
India	1352617328	1366418000	1503642000	37.4	30.0	45.3	56.3	68.1	Need to implement guidelines and protocols, need to improve acute treatments and increase the number of stroke centres in the country
Iran, Islamic Rep.	81800269	82914000	92664000	81.5	80.0	100.0	100.0	88.9	Only 1 hospital represented with good structure. The country needs to increase the number of stroke centres and the implementation of stroke treatments
Ireland	4853506	4893000	5255000	64.0	40.0	100.0	100.0	88.9	Only 1 hospital represented in the survey. The country needs to increase the number of stroke centres/stroke units and acute stroke treatments
Israel	8883800	9018000	10471000	62.1	80.0	100.0	0.0	44.4	Only 1 hospital represented. stroke centres/ stroke units may still be adequate in 2030
Italy	60431283	60340000	59196000	62.3	60.0	81.3	100.0	63.9	Same number of stroke centres/ stroke units may still be adequate in 2030
Japan	126529100	126097000	120095000	39.2	30.0	37.5	100.0	66.7	Only 1 hospital represented. The country needs to increase access to acute treatments and increase the number of stroke centres in the country
Kazakhstan	18276499	18469000	20165000	44.8	40.0	57.5	80.0	68.9	Need to implement guidelines and protocols. Same number of stroke centres/ stroke units may still be adequate in 2030
Kenya	51393010	52574000	66450000	12.3	0.0	0.0	100.0	11.1	Need to implement stroke centres and acute care in the country
Korea, Rep.	51635256	51782000	52975000	71.8	66.7	69.4	100.0	92.6	Same number of stroke centres/ stroke units may still be adequate in 2030
Kyrgyz Republic	6315800	6404000	7218000	50.7	40.0	50.0	0.0	11.1	Need to implement stroke centres and acute care in the country

Latvia	1926542	1916000	1796000	77.6	75.0	93.8	100.0	72.2	Same number of stroke centres/ stroke units may still be adequate in 2030
Lebanon	6848925	6856000	6195000	18.5	0.0	0.0	100.0	66.7	Only 1 hospital represented. Need to increase the number of stroke centres and to implement acute care treatments
Malaysia	31528585	31950000	36095000	41.5	42.5	46.9	37.5	37.5	Need to implement guidelines and protocols, to increase access to acute treatments and number of stroke centres in the country
Mexico	126190788	127576000	140876000	52.7	30.0	62.5	100.0	77.8	Need to implement guidelines and protocols, to increase access to acute treatments and number of stroke centres in the country
Moldova	3545883	3536000	3368000	57.0	65.0	53.1	50.0	48.6	Need to increase access to acute treatments and the number of stroke centres in the country
Morocco	36029138	36472000	40887000	31.6	13.3	33.3	100.0	63.0	Need to increase access to acute treatments and increase the number of stroke centres in the country
Nepal	28087871	28609000	33390000	40.3	15.0	37.5	25.0	47.2	Need to implement stroke centres and acute care in the country
New Zealand	4885500	4929000	5342000	72.9	73.3	100.0	100.0	88.9	same number of stroke centres/ stroke units may still be adequate in 2030
Nigeria	195874740	200964000	262977000	19.4	10.0	33.3	16.7	38.9	Need to implement protocols, guidelines, to increase access to acute treatments and increase the number of stroke centres in the country
North Macedonia	2082958	2083000	2051000	52.6	40.0	75.0	100.0	44.4	Only 1 hospital represented in the survey. The country needs to increase the number of stroke centres and to implement acute care treatments
Norway	5314336	5369000	5854000	59.8	46.7	66.7	100.0	100.0	Same number of stroke centres/ stroke units may still be adequate in 2030
Pakistan	212215030	216565000	262959000	41.0	0.0	100.0	0.0	44.4	Need to implement protocols, guidelines, to increase access to acute treatments and increase the number of stroke centres in the country

Panama	4176873	4246000	4928000	85.3	100.0	100.0	100.0	66.7	Same number of stroke centres/ stroke units may still be adequate in 2030
Papua New Guinea	8606316	8776000	10709000	18.8	0.0	25.0	100.0	44.4	Need to implement protocols, guidelines, to increase access to acute treatments and increase the number of stroke centres in the country
Paraguay	6956071	7045000	7950000	67.2	80.0	100.0	100.0	77.8	Only 1 hospital represented with good resources, the country needs to implement acute treatments and increase the number of stroke centres
Peru	31989256	32510000	36031000	74.8	80.0	100.0	100.0	22.2	Only 1 hospital represented, the country needs to implement acute treatments and increase the number of stroke centres
Poland	37978548	37895000	36474000	71.2	60.0	100.0	100.0	66.7	Same number of stroke centres/ stroke units may still be adequate in 2030
Portugal	10281762	10237000	9832000	40.6	32.0	42.5	90.0	74.4	Need to implement protocols, guidelines, same number of stroke centres/ stroke units may still be adequate in 2030
Russian Federation	144478050	144369000	140912000	74.2	80.0	75.0	100.0	44.4	Probably the same number of stroke centres/ stroke units may still be adequate in 2030
Rwanda	12301939	12627000	16234000	9.6	0.0	0.0	0.0	11.1	Need to implement acute treatments and stroke centres
Serbia	6982084	6955000	6625000	78.7	66.7	95.8	100.0	81.5	Same number of stroke centres/ stroke units may still be adequate in 2030
Seychelles	96762	97000	99000	19.6	10.0	25.0	0.0	33.3	Need to implement acute treatments and stroke centres
Singapore	5638676	5710000	6157000	38.0	20.0	40.0	80.0	80.0	Need to implement protocols, guidelines, acute treatments and increase the number of stroke centres
Slovak Republic	5447011	5448000	5377000	36.5	26.7	33.3	66.7	51.9	Need to implement protocols and guidelines, to improve access to acute treatments and increase the number of stroke centres in the country

South Africa	57779622	58558000	65956000	77.8	93.3	83.3	100.0	77.8	Despite the high score of 2 out of 3 centres, the country needs to improve access to acute treatments and increase the number of stroke centres in the country
Sri Lanka	21670000	21757000	22234000	26.4	5.0	18.8	75.0	47.2	Need to implement protocols and guidelines, to improve access to acute treatments and increase the number of stroke centres in the country
Sudan	41801533	42813000	55254000	29.7	0.0	25.0	100.0	27.8	Need to implement protocols and guidelines, to improve access to acute treatments and increase the number of stroke centres in the country
Sweden	10183175	10251000	10933000	39.0	20.0	25.0	100.0	97.2	Same number of stroke centres/ stroke units may still be adequate in 2030
Taiwan	23726460	23773876	24011258	60.5	53.3	66.7	100.0	88.9	Probably the same number of stroke centres/ stroke units may still be adequate in 2030
Thailand	69428524	69626000	70346000	87.7	93.3	100.0	100.0	92.6	Same number of stroke centres/ stroke units may still be adequate in 2030
Turkey	82319724	83430000	89158000	70.4	63.8	81.3	93.8	79.2	Probably the same number of stroke centres/ stroke units may still be adequate in 2030
Uganda	42723139	44270000	59438000	35.3	0.0	75.0	0.0	33.3	Need to implement stroke centres and acute care in the country
Ukraine	44622516	44391000	41719000	60.1	35.0	81.3	100.0	77.8	Need to implement protocols, guidelines, increase the number of stroke centres
United Arab Emirates	9630959	9771000	10661000	1.2	0.0	0.0	0.0	11.1	Need to implement stroke centres and acute care in the country
United Kingdom	66488991	66856000	70277000	42.0	31.3	39.1	100.0	85.4	Need to implement protocols, guidelines and increase access to acute stroke treatments
United States	327167434	329534000	354448000	57.1	52.0	66.7	80.0	78.5	same number of stroke centres/ stroke units may still be adequate in 2030
Uruguay	3449299	3462000	3569000	82.9	80.0	100.0	100.0	77.8	Despite the high score of this single centre, the country needs to implement protocols and guidelines, increase access to acute stroke

									treatments and increase the number of stroke centres
Vietnam	95540395	96462000	104164000	63.0	60.0	100.0	100.0	77.8	Same number of stroke centres/ stroke units may still be adequate in 2030
Wales	3,139,308	3,151,569	3,234,289	21.0	0.0	0.0	100.0	88.9	Need to implement protocols, guidelines, increase access to acute stroke treatments and increase the number of stroke centres

* Completed number of items answered (median) out of a total of 104.

Limitations with generalizability. Data used to generate table was collected in 2017 and details published[2]

Supplementary Table 14. Summary of barriers and facilitators to acute stroke care services

	Barrier	Facilitator	Recommendation
Service provision	• Inequalities in stroke care by geography or socioeconomic status • Government funding for stroke care does not cover all services • Lack of community awareness limits access to care • No national strategy or guidelines	• Development and implementation of national stroke plans or guidelines Increasing evidence-base for new therapies drives investment and awareness of stroke • Training in stroke care increases capacity to deliver services • Collection of data on stroke care and outcomes drives improvements	• Create national plan for stroke with regional networks to increase access to care • Create structured, regular training for general physicians to increase capacity for stroke care
Funding	• Tension between public and private health care systems • Stroke is not a priority for governments • No universal health care decreases access to evidence-based care	• Availability of services across public and private systems increased access across countries • Universal health care or low-cost services ensures access for more people • Data collection on stroke care provides mechanisms for funding through government	• Collect data on stroke care and outcomes to lobby for funding to meet community needs • Lobby for universal health care or inclusion of evidence-based care in government-funded services
Workforce	• Few staff with stroke specific training • Remuneration in public compared to private sector • Brain drain from ow and middle income countries	• Provision of training to a wide range of health professionals • Importance of nurses to provision of high-quality care • Motivated staff including through incentives, e.g., bonuses, research, awards	• Create plans for training and retaining staff in stroke including professional development and other incentives
Data and information systems	• No funding for data collection • Lack of national strategy for collection of data • Data limited to acute care and short-term outcomes • Lack of interoperability between electronic medical record systems	• National or local registries collect stroke care data used for quality improvement including awards • Data are used to increase stroke awareness and advocacy • Existing systems can be used for collection in many settings, e.g., RES-Q or SITS	• Develop and implement national data collection for key stroke care and outcomes • Use data to advocate for stroke and leverage funding • Work with IT specialists to increase interoperability of electronic medical records systems
Technology	• No formal infrastructure for telehealth • Electronic medical records only in some hospitals for some data • Lack of access to newer imaging modalities across countries • Desire for new technology, e.g., AI, mobile stroke units, robotics, but no funding	• Telehealth networks either formal through government or informal using free technology, e.g. What's App • Government investment in innovations, e.g., mobile stroke units, advanced imaging, robotics • Electronic medical records provide some data on stroke at most levels of hospital system	• Create national telehealth networks with funding for services provided • Increase evidence-base for mobile stroke units • Increase coverage of electronic medical records
Governance	• No national strategy for stroke care • Lack of political will to invest in stroke	• Development of national stroke strategy and/or guidelines	• Create a national strategy for stroke including management guidelines with 'living' models

• Under-developed professional networks for stroke • No accreditation for stroke care • Low community awareness of stroke	• National professional networks for stroke with strong leadership with influence in government • Accreditation or certification of stroke care drives improvements • Increasing community and health professional awareness of stroke	• Foster national professional organizations for stroke care and advocacy • Explore mechanisms to certify or accredit delivery of stroke care

Supplementary Table 15: Key evidence-based recommendations to improve acute stroke care worldwide

Key recommendations	Source	Level of evidence/ GRADE	Resources required for implementation	Political, legal, ethical, sociocultural and economic considerations and barriers for	Recommendation for contextualization and implementation through WSO Task Force on Stroke and implementation ecosystem
For all stroke patients					
Patients with an acute stroke should be admitted to hospital	WSO Guideline and Action Plan[15,281]	Level A	Hospitals available (preferably stroke centres)	Some regions without hospitals	Governments should map the country and build at least 1 hospital per region (ideally every 200-250 km, preferably a stroke centre). Online roadmap can help in the evaluation
All patients with suspected acute stroke should receive brain imaging evaluation on arrival to hospital (non-contrast CT – NCCT – or Magnetic Resonance - MRI)	AHA Guideline for Acute Stroke[282] Canadian Guidelines[283] ICH Guidelines AHA/ASA[276]	Level 1A[1] Level A Level 1A	Availability of CT scan in hospitals	Lack of resources to equip more hospitals with NCCT scan	Governments should map the country and implement at least 1 CT scan equipment every 200 km. Online roadmaps can help in the evaluation
Patients with acute stroke or TIA admitted to a hospital should be treated by an interdisciplinary stroke team (at least a physician with training in stroke care, a nurse, physiotherapist and speech therapist)	Canadian Guidelines[283] WSO Guideline and Action plan[15] Action plan for stroke in Europe[11]	Level A Level A Level A	Interdisciplinary stroke team	Lack of knowledge of health managers that interdisciplinary team is cost effective and improves the patient's outcomes Lack of training for the interdisciplinary team	WSO implementation ecosystem on Stroke commissioners to work together with the health managers to show the evidence about interdisciplinary stroke team Educational teaching courses for the stroke team (online – World Stroke Academy) and face to face with local societies
Patients with acute stroke or TIA admitted to a hospital should be treated in a stroke unit, which is a specialized, geographically defined area dedicated to the management of stroke patients with an interdisciplinary stroke team	Canadian Guidelines[283] WSO Guideline and Action plan[15] Action plan for stroke in Europe[11] Declaration of Gramado[32]	Level A Level A Level A	Geographic area in the hospital Interdisciplinary stroke team	Lack of space to create stroke units Lack of resources Lack of knowledge of health managers that interdisciplinary team is cost effective and improves the patient's outcomes Lack of training for the interdisciplinary team	WSO implementation ecosystem on Stroke commissioners to work together with health managers and local societies to show the evidence about stroke units and to create plans to organize them more than built new areas Educational teaching courses for the stroke team members (online – World Stroke Academy) and face to face meetings with local societies
Patients should be evaluated and managed to prevent complications (early access to swallowing, nutrition and	Canadian Guidelines[283] WSO Guideline and Action plan[15]	Level A Level A	Training for the stroke team	Lack of knowledge of health professionals about the importance of these general actions	Educational teaching courses for the stroke team (online – World Stroke Academy) and

hydration status, fever, glucose, oxygen saturation, blood pressure, deep vein thrombosis, skin ulcers)	Action plan for stroke in Europe[11] AHA Guidelines[282]	Level A Level A		Lack of training for the interdisciplinary team	face to face with local societies/professionals
In remote regions without doctors with stroke expertise, telemedicine in community hospitals may help to provide acute stroke treatment, including thrombolysis.	AHA,[282] Canadian,[283] Action plan in Europe,[11] Declaration of Gramado[32]	Level IIa, B-R	Tools for communication and image evaluation in real time Stroke experts to give consultation 24h/day, 7 days a week	Lack of communication and image transfer tools Low resources to pay the equipment and professionals	WSO implementation ecosystem on Stroke commissioners to work together with health managers and hospitals to develop a network to increase the access to stroke treatment in areas without doctors with stroke expertise.
Specific for Ischemic stroke/TIA					
Patients with TIA should be assessed in hospital or if not possible, in a specialized outpatient clinic to perform CT scan, evaluate stroke aetiology and immediately to start stroke prevention (within 48 hours from symptoms onset)	Canadian Guidelines[283] WSO Guideline and Action plan[15] Action plan for stroke in Europe[11]	Level A Level A	Training for health professionals Organization of TIA acute assistance	Lack of awareness of health professionals about the importance to evaluate TIA and minor stroke as a medical urgency Lack of structure for a fast evaluation of AIT aetiology and prevention treatment initiation	WSO implementation ecosystem on Stroke commissioners to develop strategies and action plans for education of health professionals to treat TIA as a medical urgency and to educate them with the best prevention strategies starting immediately after symptoms onset.
Patients with ischemic stroke should be evaluated for IV thrombolysis with tPA up to 4,5 hours of symptoms onset	AHA,[282] Canadian Guidelines,[283] WSO,[15] Action plan in Europe.[11] Declaration of Gramado[32] ESO Guideline[284]	Level 1A	Availability of tPA; Training for stroke professionals; Organization of pathways for fast treatment	Lack of knowledge of health managers about the benefit and cost-effectiveness of the thrombolytic treatment lack of trained doctors and interdisciplinary team lack of thrombolytic medication in some countries cost of medication	WSO implementation ecosystem on Stroke commissioners to work together with health managers and local societies to show the evidence about IV thrombolysis and to create plans to implement treatment; teaching courses; telemedicine is an effective and cost-effective tool to help the implementation in areas without stroke expertise doctors.[78,79] Governments should discuss with companies to ensure affordable thrombolytic medication
Ischemic stroke patients should be given acetylsalicylic acid (ASA) as soon as possible within 48 hours from symptom onset after brain imaging has excluded intracranial haemorrhage. Thrombolysed patients should receive ASA 24 hours after treatment	AHA,[282] Canadian Guidelines,[283] WSO,[15] Action plan in Europe.[11]	Level 1A	Health professional education	Lack of medical education	Educational teaching courses for the stroke team (online – World Stroke Academy) and face to face with local societies/professionals
Patients with minor stroke (NIHSS ≤ 3) who did not receive IV alteplase or high-risk TIA (ABCD2 score >4) of non-cardioembolic origin should receive dual antiplatelet	AHA,[282] Canadian Guidelines,[283]	Level 1A Level 1A	Training for the stroke team	Lack of medical education	Educational teaching courses for the stroke team (online – World Stroke Academy) and

therapy (DAPT) up to 24 hours of symptoms onset with aspirin plus clopidogrel (loading dose 300 or 600 mg followed by 75 mg/day). DAPT should continue for 21 to 30 days. After, should continue antiplatelet monotherapy indefinitely					face to face with local societies/professionals
Patients with Large Vessel Occlusion (LVO) with symptoms up to 24 hours should be evaluated for mechanical thrombectomy (MT) in comprehensive stroke centres (Advanced as the WSO Roadmap classification).	AHA,[282] Canadian Guidelines,[283] WSO,[15] Action plan in Europe.[11]	Level 1A	Comprehensive stroke centres (advanced) Neurointerventionalists trained available 24h, 7 days a week, anaesthesiologist, Access to Angiography units, devices for MT	Lack of knowledge of health managers about the benefit of the treatment lack of structure in hospitals (usually LIC without any advanced hospital) lack of resources to pay the professionals and devices lack of trained neuro-interventionalists	WSO implementation ecosystem on Stroke commissioners to work together with health managers and local societies to show the evidence already available and to create plans to implement treatment, teaching courses, hands-on in high volume centres. Governments should discuss with companies to ensure affordable devices and materials
Patients eligible for IV thrombolysis should receive IV thrombolysis even if MT is being considered.	AHA,[282] Canadian Guidelines,[283] ESO Guideline.[284]	Level 1A Level 1A	Training for the stroke team	Lack of medical education	Educational teaching courses for the stroke team (online – World Stroke Academy) and face to face with local societies/professionals
Specific for intracerebral haemorrhage (ICH)					
In patients with spontaneous ICH of mild to moderate severity presenting with SBP between 150 and 220 mmHg, acute lowering of SBP to a target of 140 mmHg (maintaining in the range of 130 to 150 mm Hg) is safe and may be reasonable for improving functional outcomes	AHA ICH[276]	Level 1A	Training for the stroke team	Lack of medical education	Educational teaching courses for the stroke team
In patients with spontaneous ICH presenting within 6 h of the onset of the event, the use of a care bundle protocol incorporating the early control of elevated blood pressure (SBP < 140 mm Hg within 1 h of the initiation of treatment) together with management algorithms for hyperglycaemia (achieving a glucose target of 6·1–7·8 mmol/L for patients without diabetes and 7·8–10·0 mmol/L for patients with diabetes as soon as possible after the initiation of treatment), pyrexia (achieving a body temperature of <37·5°C within 1 h of initiation), and he reversal of abnormal anticoagulation in those taking warfarin using fresh frozen plasma or prothrombin concentrate complex with the goal of reaching an international normalised ratio of less than 1·5 within 1 h	INTERACT3[285]	Level 1A	Training for the stroke team	Lack of medical education	Educational teaching courses for the stroke team

of treatment. Maintaining these treatment targets for 7 days or until discharge results in an improved functional outcome at 6 months.					
In patients with spontaneous ICH and clinical hydrocephalus, transfer to centres with neurosurgical capabilities for definitive hydrocephalus management with external ventricular derivation (EVD) placement and monitoring is recommended to reduce mortality	AHA ICH[276]	Level 1-BNR	Training for the stroke team	Lack of medical education	Educational teaching courses for the stroke team
Intermittent pneumatic compression (IPC) starting on the day of diagnosis is recommended for deep venous thrombosis and pulmonary embolism prophylaxis	AHA ICH[276]	Level 1-BR	Training for the stroke team	Lack of medical education	Educational teaching courses for the stroke team
In patients with spontaneous ICH, impaired consciousness, and confirmed electrographic seizures, antiseizure drugs should be administered to reduce morbidity	AHA ICH[276]	Level 1-CLD	Training for the stroke team	Lack of medical education	Educational teaching courses for the stroke team
In patients with clinical seizures antiseizure drugs should be administered	AHA ICH[276]	Level 1 CEO	Training for the stroke team	Lack of medical education	Educational teaching courses for the stroke team
For patients with cerebellar ICH who are deteriorating neurologically, have brainstem compression and/or hydrocephalus from ventricular obstruction, or have cerebellar ICH volume ≥15 mL, immediate surgical removal of the haemorrhage with or without EVD is recommended in preference to medical management alone to reduce mortality	AHA ICH[276]	Level 1 BNR	Training for the stroke team Availability of operating room and neurosurgeon 24h, 7 days	Lack of medical education Unavailability of structure to the surgery (equipment and professional)	Educational teaching courses for the stroke team. If unavailability of resources, the patient should be transferred to a hospital with neurosurgery Plans to transfer these patients should be coordinated with health managers as regional protocol
ICH while anticoagulated: -Acute reversal of anticoagulation using protein complex concentrate (PCC) more than fresh frozen plasma for reversal of vitamin K antagonists followed immediately by IV Vitamin K to avoid increased INR again. - Idarucizumab for reversal of the thrombin inhibitor dabigatran -Andexanet alfa for reversal of factor Xa inhibitors such as Rivaroxaban, Apixaban, and Edoxaban.	AHA ICH[276]	Level 1 BR Level 1 CLD Level 2a BNR Level 2a BNR	Training for the stroke team Availability of PCC Training for the stroke team, availability of Idarucizumab Training for the stroke team, availability of Andexanet	Lack of medical education Lack of medication for anticoagulation reversal Lack of medical education Lack of medication for anticoagulation reversal Lack of medical education Lack of medication for anticoagulation reversal	Educational teaching courses for the stroke team. Director of hospital and Health managers should provide medication for anticoagulation reversal Educational teaching courses to the stroke team Director of hospital and Health managers should provide medication for anticoagulation reversal

Specific for subarachnoid haemorrhage (SAH)					
Acute diagnostic workup should include non-contrast head CT, which, if nondiagnostic, should be followed by lumbar puncture	AHA SAH[286]	1B	Availability of CT scan and lumbar puncture material in the hospital	Lack of resources to equip more hospitals	Governments should map the country and implement at least 1 CT scan equipment every 200 km. Online Roadmap can help in the evaluation
CTA may be considered in the workup of aSAH. If an aneurysm is detected by CTA, this study may help guide the decision for type of aneurysm repair, but if CTA is inconclusive, Diagnostic subtraction angiography still recommended (except possibly in the instance of classic perimesencephalic aSAH)		2B, C	Availability of CTA	Lack of resources to equip more hospitals	Governments should plan and implement at least 1 comprehensive (advanced) stroke centre to each 2 million inhabitants Coordinated routes to transfer these patients in the first 24 hours should be organized.
The magnitude of blood pressure control to reduce the risk of rebleeding has not been established, but a decrease in systolic blood pressure to <160 mmHg is reasonable	AHA SAH[286,287]	Level C, 2A,	Training for health professionals	Lack of training	Educational teaching courses for the stroke team.
Patients with SAH should start oral nimodipine to improve outcomes but not to decrease vasospasm	AHA SAH[286,287]	Level 1A	Training for health professionals	Lack of training Lack of nimodipine	Educational teaching courses for the stroke team. Health managers should ensure that essential medication is available
Surgical clipping or endovascular coiling of the ruptured aneurysm should be performed as early as feasible in the majority of patients to reduce the rate of rebleeding after aSAH	AHA SAH[286,287]	Level 1 B	Availability of neurosurgeon or neurointerventionalists, availability of surgery room or angio-suite	Lack of equipment and professionals	Educational teaching courses for neurosurgeon, neurointerventionalists Comprehensive (advanced) stroke centre available in the region to transfer the patient
A neuroradiologist and a neurosurgeon should discuss the options for managing the culprit aneurysm (endovascular coiling or neurosurgical clipping), taking into account the patient's clinical condition, the characteristics of the aneurysm, and the amount and location of subarachnoid blood	AHA SAH[286,287]		1B	Lack of training	Educational teaching courses to neurosurgeon, neurointerventionalist

Supplementary Table 16: Estimated coverage and unmet needs for rehabilitation, according to country

Country Name	Population 2018	Population 2019	Projected Population 2030	Estimated Coverage for rehabilitation services			Estimated Unmet Needs*
				In patient	community	Section score	
Albania	2866376	2867000	2830000	0	0	33.33	Need to provide qualitative and high number of in-patient and out-patient facilities
Argentina	44494502	44901000	49069000	66.67	0	22.22	Need to provide qualitative and high number of in-patient and out-patient facilities
Armenia	2951776	2958000	2967000	50	0	1	Need to provide qualitative and high number of in-patient and out-patient facilities
Aruba	105845	106000	110000	0	0	0	Need to provide qualitative and high number of in-patient and out-patient facilities
Australia	24992369	25303000	28393000	75	25	33.33	Need to provide qualitative and high number of in-patient and out-patient facilities
Austria	8847037	8865000	9017000	100	50	55.56	Need to provide qualitative and high number of in-patient and out-patient facilities
Bangladesh	161356039	163046000	178994000	50	0	5.56	Same number of facilities may still be adequate in 2030.
Belarus	9485386	9467000	9191000	100	0	22.22	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable Need to provide qualitative and high number of in-patient and out-patient facilities
Belgium	11422068	11483000	11904000	100	50	55.56	Need to provide qualitative and high number of in-patient and out-patient facilities
Benin	11485048	11801000	15672000	100	0	22.22	rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Bolivia	11353142	11513000	13240000	100	0	11.11	Need to provide qualitative and high number of in-patient and out-patient facilities
Brazil	209469333	211050000	223852000	87.5	8.33	21.3	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Bulgaria	7024216	6970000	6338000	100	50	55.56	Need to provide qualitative and high number of in-patient and out-patient facilities
Burkina Faso	19751535	20321000	27404000	0	0	0	Need to provide qualitative and high number of in-patient and out-patient facilities
Cameroon	25216237	25876000	33766000	100	0	22.22	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable

Canada	37058856	37375000	40352000	0	0	0	Only one hospital completed the survey, and only 2 of 17 questions answered. This is unlikely to represent rehabilitation care in this region.
Chile	18729160	18952000	19458000	100	66.67	62.96	Need to provide qualitative and high number of in-patient and out-patient facilities
China	1392730000	1397295000	1416292000	100	0	24.44	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Colombia	49648685	50339000	53417000	75	25	44.44	Need to provide qualitative and high number of in-patient and out-patient facilities
Congo, Dem. Rep.	84068091	86791000	120047000	100	0	11.11	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Costa Rica	4999441	5048000	5468000	100	0	29.63	Need to provide qualitative and high number of in-patient and out-patient facilities
Croatia	4089400	4071000	3864000	100	36.36	44.44	Need to provide qualitative and high number of in-patient and out-patient facilities
Czech Republic	10625695	10629000	10491000	100	0	27.78	Need to provide qualitative and high number of in-patient and out-patient facilities
Denmark	5797446	5818000	6047000	100	0	33.33	Need to provide qualitative and high number of in-patient and out-patient facilities
Egypt, Arab Rep.	98423595	100388000	120832000	100	0	25.93	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Estonia	1320884	1317000	1265000	100	100	55.56	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Ethiopia	109224559	112079000	144944000	20	0	11.11	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
France	66987244	67211000	69509000	100	0	26.67	Need to provide qualitative and high number of in-patient and out-patient facilities
Georgia	3731000	3721000	3562000	100	0	33.33	Same number of facilities may still be adequate in 2030.
Germany	82927922	82806000	81520000	100	25	36.11	Same number of facilities may still be adequate in 2030
Ghana	29767108	30418000	37833000	100	0	38.89	Need to provide qualitative and high number of in-patient and out-patient facilities
Greece	10727668	10696000	10355000,	100	0	44.44	Need to provide qualitative and high number of in-patient and out-patient facilities
Honduras	9587522	9746000	11449000	100	100	100	Need to provide more in-patient and out-patient facilities towards 2030

Hong Kong	7451000	7508000	8024000	100	100	88.89	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Hungary	9768785	9732000	9292000	100	0	22.22	Same number of facilities may still be adequate in 2030
India	1352617328	1366418000	1503642000	68.75	6.25	25	Need to provide qualitative and high number of in-patient and out-patient facilities
Iran, Islamic Rep.	81800269	82914000	92664000	100	0	44.44	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Ireland	4853506	4893000	5255000	100	0	22.22	Need to provide qualitative and high number of in-patient and out-patient facilities
Israel	8883800	9018000	10471000	100	0	44.44	Need to provide qualitative and high number of in-patient and out-patient facilities
Italy	60431283	60340000	59196000	100	0	41.67	Need to provide qualitative and high number of in-patient and out-patient facilities
Japan	126529100	126097000	120095000	100	0	16.67	Same number of facilities may still be adequate in 2030
Kazakhstan	18276499	18469000	20165000	100	0	28.89	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Kenya	51393010	52574000	66450000	0	0	0	Need to provide qualitative and high number of in-patient and out-patient facilities
Korea, Rep.	51635256	51782000	52975000	100	11.11	48.15	Same number of facilities may still be adequate in 2030
Kyrgyz Republic	6315800	6404000	7218000	100	0	33.33	Need to provide qualitative and high number of in-patient and out-patient facilities
Latvia	1926542	1916000	1796000	100	75	50	Same number of facilities may still be adequate in 2030
Lebanon	6848925	6856000	6195000	0	0	0	Need to provide qualitative and high number of in-patient and out-patient facilities
Malaysia	31528585	31950000	36095000	75	37.5	40.3	Need to provide qualitative and high number of in-patient and out-patient facilities
Mexico	126190788	127576000	140876000	100	50	50	Need to provide qualitative and high number of in-patient and out-patient facilities
Moldova	3545883	3536000	3368000	87.5	12.5	33.33	Same number of facilities may still be adequate in 2030
Morocco	36029138	36472000	40887000	100	0	14.81	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Nepal	28087871	28609000	33390000	75	25	31.94	Need to provide qualitative and high number of in-patient and out-patient facilities
New Zealand	4885500	4929000	5342000	100	33.33	55.56	Need to provide qualitative and high number of in-patient and out-patient facilities

Nigeria	195874740	200964000	262977000	66.67	0	22.22	Need to provide qualitative and high number of in-patient and out-patient facilities
North Macedonia	2082958	2083000	2051000	100	0	22.22	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Norway	5314336	5369000	5854000	100	33.33	51.85	Same number of facilities may still be adequate in 2030
Pakistan	212215030	216565000	262959000	100	0	44.44	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Panama	4176873	4246000	4928000	100	0	44.44	Need to provide qualitative and high number of in-patient and out-patient facilities
Papua New Guinea	8606316	8776000	10709000	100	0	11.11	Need to provide qualitative and high number of in-patient and out-patient facilities
Paraguay	6956071	7045000	7950000	100	0	22.22	Need to provide qualitative and high number of in-patient and out-patient facilities
Peru	31989256	32510000	36031000	100	0	22.22	Need to provide qualitative and high number of in-patient and out-patient facilities
Poland	37978548	37895000	36474000	100	0	33.33	Need to provide qualitative and high number of in-patient and out-patient facilities
Portugal	10281762	10237000	9832000	90	10	30	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Russian Federation	144478050	144369000	140912000	100	0	38.89	Need to provide qualitative and high number of in-patient and out-patient facilities
Rwanda	12301939	12627000	16234000	100	0	44.4	Need to provide qualitative and high number of in-patient and out-patient facilities
Serbia	6982084	6955000	6625000	100	50	55.56	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Seychelles	96762	97000	99000	50	0	16.67	Need to provide qualitative and high number of in-patient and out-patient facilities
Singapore	5638676	5710000	6157000	100	20	37.78	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Slovak Republic	5447011	5448000	5377000	66.67	0	25.93	Need to provide qualitative and high number of in-patient and out-patient facilities
South Africa	57779622	58558000	65956000	100	33.33	70.37	Need to provide qualitative and high number of in-patient and out-patient facilities
Sri Lanka	21670000	21757000	22234000	50	0	5.56	Need to provide qualitative and high number of in-patient and out-patient facilities

Sudan	41801533	42813000	55254000	100	0	11.11	Need to provide qualitative and high number of in-patient and out-patient facilities
Sweden	10183175	10251000	10933000	100	25	33.33	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Taiwan	23726460	23773876	24011258	100	50	55.56	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Thailand	69428524	69626000	70346000	100	100	81.48	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Turkey	82319724	83430000	89158000	100	37.5	48.61	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Uganda	42723139	44270000	59438000	0	0	0	Need to provide qualitative and high number of in-patient and out-patient facilities
Ukraine	44622516	44391000	41719000	100	25	44.44	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
United Arab Emirates	9630959	9771000	10661000	100	0	33.33	Need to provide qualitative and high number of in-patient and out-patient facilities
United Kingdom	66488991	66856000	70277000	100	25	37.5	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
United States	327167434	329534000	354448000	80	40	40.74	Rigorous epidemiological surveillance for stroke to make these quantitative projections reliable
Uruguay	3449299	3462000	3569000,	100	0	44.44	Need to provide qualitative and high number of in-patient and out-patient facilities
Vietnam	95540395	96462000	104164000	100	0	44.44	Need to provide qualitative and high number of in-patient and out-patient facilities
Wales	3,139,308	3,151,569	3,234,289	100	0	11.11	Need to provide qualitative and high number of in-patient and out-patient facilities

All data were obtained from the World Bank site (obtained from https://data.worldbank.org/indicator/SP.POP.TOTL), except for Taiwan (obtained from https://population.un.org/wpp2019/Download/Standard/Population/); DHS, Demographic Health Survey. Please note that for all the countries, there is a need for more rigorous epidemiological surveillance of stroke burden to make more reliable projections. Nevertheless, nearly all the countries need to provide qualitative and high number of in-patient and out-patient facilities with more units being needed according to projected population growth.

Limitations with generalizability. Data used to generate table was collected in 2017 and details published[2]

Supplementary Table 17. Barriers and facilitators for improving stroke rehabilitation services

	Barriers	Facilitators	Recommendations
Workforce	Gaps outside physiotherapy in psychology, speech pathology, occupational therapy Not enough staff and low staff retention with dependency on small numbers of people Lack of awareness of interdisciplinary stroke rehabilitation in recovery Lack of coordinated leadership	Growing awareness of the role of interdisciplinary stroke rehabilitation Availability of multidisciplinary care across several settings Professionalisation of allied health including stroke specialisation Communities of practice for allied health in stroke	Ensure local stroke-specific training of all allied health specialties Consider task shifting to allied health assistants Create national plans to promote awareness of stroke rehabilitation Create regional communities of practice to support allied health staff
Service provision	Inequality in access to stroke rehabilitation – geography, income, age Complexity of pathways Lack of interdisciplinary services, e.g., psychology, occupational therapy, speech pathology Funding for services too low or limited in scope Small number of individuals relied on to provide all services	Patchwork of services across settings offer options for rehabilitation Better trained staff led to better evidence-based care Clinical guidelines, protocols or frameworks Motivated workforce focused on patient outcomes Raising awareness of rehabilitation after stroke across stakeholder groups	Use clinical guidelines to promote best practice care including all specialities Embed telerehabilitation to increase access to care across regions Lobby for increased funding for rehabilitation across settings and specialities
Finance	Universal health care covers limited range of services for a short time Services only accessible through a user pays system Funding models are complex Governments not prioritising stroke as a public health issue Stroke impacts on the person's financial wellbeing affecting their family and their access to care	Universal health care provides safety net of some rehabilitation for most people Government funding supports some infrastructure in mostly large tertiary hospitals User pays services play an important role in providing access to rehabilitation	Ensure all countries have universal health care Lobby for coverage of all allied health specialties across settings in government-funded services Ensure private health insurers fund evidence-based stroke rehabilitation
Data and information	Electronic medical records not standard across countries or settings Data on numbers of strokes collected at hospital level but not used for country-wide service planning Data available for in-patient rehabilitation in public system but not private system or community/home settings	Individual hospitals collect rehabilitation data to use for quality improvement Electronic medical records becoming common but mostly for operational reasons Covid pandemic has shown power of data for decision making	Expand electronic medical records and include a range of settings Make data available at a national level for planning
Technology	Technology for rehabilitation is expensive for devices and staffing	Electronic data capture integrated into clinical care Innovative organizations are developing and implementing technology	Ensure hospitals are equipped for telerehabilitation

	Not common to have advanced technology like robotics in rehabilitation services Lack of awareness and/or evidence for advanced technologies in rehabilitation Most hospitals not equipped to deliver telerehabilitation	Covid pandemic forced the use of telerehabilitation Digital tools like smartphones can be used to deliver rehabilitation	Build evidence base for advanced technologies in rehabilitation
Governance	Complex governance over disciplines and settings Defining clinical excellence challenging due to range of specialities and patient needs Policy settings not amenable to changes in delivery of rehabilitation Governing bodies do not see stroke as priority Lack of regional collaboration/frameworks for rehabilitation	Non-government stroke organizations improve awareness and quality of rehabilitation Registration bodies for allied health including subspecialisation in stroke improves care Existing government structures provide oversight for clinical care Clinical guidelines improve the quality of rehabilitation care Individuals in government act as champions for stroke rehabilitation	Create transparent information about rehabilitation pathways across all settings for the community, health professionals and policy makers Create national stroke advocacy organizations to build capacity and awareness

Supplementary Table 18: Survey on the implementation of WFNR stroke rehabilitation practice recommendations - participant characteristics and settings

		Total (n, %)	HIC group (n, %)	LMIC group (n, %)	*P* (Chi^2)
Age group (years):	<30	6 (9%)	2 (11%)	4 (9%)	0.1152
	<40	18 (27%)	5 (26%)	13 (28%)	
	<50	22 (33%)	4 (21%)	18 (38%)	
	<60	12 (18%)	7 (37%)	5 (11%)	
	≥60	8 (12%)	1 (5%)	7 (15%)	
Sex	Female	36 (55%)	7 (37%)	29 (62%)	0.0663
Education	High school	1 (2%)	1 (5%)	0	0.0512
	Bachelor	10 (15%)	1 (5%)	9 (20%)	
	Master	13 (20%)	4 (21%)	9 (20%)	
	Medical Doctor	20 (31%)	3 (16%)	17 (37%)	
	PhD	20 (31%)	9 (47%)	11 (24%)	
	Other	1 (2%)	1 (5%)	0	
Profession	Medical Doctor	38 (58%)	10 (53%)	28 (60%)	0.1997
	Nurse	0	0	0	
	Occupational Therapist	2 (3%)	0	2 (4%)	
	Psychologist	1 (2%)	0	1 (2%)	
	Physiotherapist	21 (32%)	7 (37%)	14 (30%)	
	Speech and Language Therapist	2 (3%)	0	2 (4%)	
	Other	2 (3%)	2 (11%)	0	
Experience in neurorehabilitation (years)	0	2 (3%	0	2 (4%)	0.5674
	<2	3 (5%)	0	3 (6%)	
	<5	13 (20%)	5 (26%)	8 (17%)	
	<10	8 (12%)	3 (16%)	5 (11%)	
	≥10	40 (61%)	11 (58%)	29 (62%)	
Type of service	Acute care	20 (30%)	6 (32%)	14 (30%)	0.0245
	Early rehabilitation	6 (9%)	5 (26%)	1 (2%)	
	Inpatient rehabilitation	19 (29%)	6 (32%)	13 (28%)	
	Outpatient rehabilitation	16 (24%)	2 (11%)	14 (30%)	
	Single profession outpatient service	2 (3%)	0	2 (4%)	
	Other	3 (5%)	0	3 (6%)	
Region (World Bank region classification)	East Asia & Pacific	22 (33%)	2 (11%)	20 (43%)	<0.0001

	Europe & Central Asia	14 (21%)	14 (74%)	0
	Latin America & Caribbean	10 (15%)	1 (5%)	9 (19%)
	Middle East & North Africa	6 (9%)	2 (11%)	4 (9%)
	South Asia	4 (6%)	0	4 (9%)
	Sub-Saharan Africa	10 (15%)	0	10 (21%)
World Bank country economical classification	High income countries (HIC)	19 (29%)		
	Low and (lower and upper) middle income countries	47 (71%)		

Abbreviations: P (Chi^2) - P value for Chi^2 test when comparing distributions for HIC and LMIC respondents. *Note:* percentage is rounded for each category, thus total might deviate from 100%. Education: analysis based on entries provided by 65 respondents (1 missing).

Supplementary Table 19: Frequency of implementation of team oriented WFNR stroke rehabilitation practice recommendations

		Total (n, %)	HIC group (n, %)	LMIC group (n, %)	*P* (Chi²)
REC 1 – Team (n=66) If possible, stroke rehabilitation should be delivered by interdisciplinary teams with specific training and experience in the field.	A	24 (36%	10 (53%)	14 (30%)	0.0404
	B	25 (38%)	8 (42%)	17 (36%)	
	C	17 (26%)	1 (5%)	16 (34%)	
	D	0	0	0	
REC 2 – Initiation (n=65) Initiation: The early rehabilitation process after stroke should be initiated in stroke units.	A	22 (34%)	10 (56%)	12 (26%)	0.1187
	B	29 (45%)	5 (28%)	24 (51%)	
	C	12 (18%)	3 (17%)	9 (19%)	
	D	2 (3%)	0	2 (4%)	
REC 3 – Continuation (n=65) Since the rehabilitation process after stroke will rarely be complete when it is time to leave hospital, rehabilitation should be continued after discharge especially during the first year after stroke to reduce the risk of disability and may individually be needed at later stages.	A	15 (23%)	2 (11%)	13 (28%)	0.0274
	B	37 (57%)	15 (83%)	22 (47%)	
	C	13 (20%)	1 (6%)	12 (26%)	
	D	0	0	0	
REC 4 – Integration (n=65) For delivering high-quality healthcare for stroke survivors, the integration (in contrast with fragmentation) of care providers (e.g., specialists, general practitioners and other healthcare providers such as pharmacists, nurses, psychologists, physiotherapists) and close coordination (multidisciplinary care) of their activities across levels of care and multiple sites is warranted, all of which can be optimally embedded within a system that promotes patient empowerment.	A	14 (22%)	3 (17%)	11 (23%)	0.5546
	B	24 (36%)	9 (50%)	15 (32%)	
	C	26 (40%)	6 (33%)	20 (43%)	
	D	1 (2%)	0	1 (2%)	
REC 5 – Action planning (n=64) Heightened attention should be paid to evaluate team processes related to assessing/reporting of clinical findings and to goal setting and action planning processes. This includes to review the structure of team meetings, encourage the use of standardized measurement tools and assessments for clinical status and progress monitoring and the explicit method used for goal setting and action planning.	A	19 (30%)	7 (41%)	12 (26%)	0.4913
	B	19 (30%)	4 (24%)	15 (32%)	
	C	23 (36%)	6 (35%)	17 (36%)	
	D	3 (5%)	0	3 (6%)	
REC 6 – ICF (n=65) All domains, including the body functions and structures (impairment), the activity and participation as well as the environmental factors domain of the ICF, can be used as a common language for professionals when setting goals in a semi-structured, 'guided' manner. Using the main ICF activity and participation domain as broad goal categories will prevent the missing of important goal areas, such as interactions and relations and social and civil life.	A	11 (17%)	3 (17%)	8 (17%)	0.5259
	B	28 (43%)	10 (56%)	18 (38%)	
	C	24 (37%)	5 (28%)	19 (40%)	
	D	2 (3%)	0	2 (4%)	
REC 7 – GOALS (n=65) Heightened attention can be paid to the goal syntax (starting with a verb, denominating a task, followed by modifiers, denominating the circumstances to accomplish the task). Patient's perceptions/appraisal of goal importance, goal difficulty, self-efficacy and emotional stability can be checked, as they will mainly impact on individual goal choice and ranking and how to avoid goal conflicts. Evaluation of goal achievement (appraisal and feedback) can be used as a distinct and important intervention aiming to enhance self-efficacy and set the basis for (guided) self-management, marking the transition from 'therapy' (receptive) to 'training' (active, self-set).	A	17 (26%)	3 (17%)	14 (30%)	0.3642
	B	27 (42%)	8 (44%)	19 (40%)	
	C	18 (28%)	7 (39%)	11 (23%)	
	D	3 (5%)	0	3 (6%)	

Abbreviations: P (Chi^2) - P value for Chi^2 test when comparing distributions for HIC and LMIC respondents. *Levels of implementation*: A: Can regularly be applied as indicated, B: Can be applied regularly, but less than indicated, C: Can be applied, but only to a limited extent / much less than indicated, D: Cannot be applied. *Note*: percentage is rounded for each category, thus total might deviate from 100%.

Supplementary Table 20. Key Recommendations based on National Stroke Guidelines and WFNR recommendations to improve stroke rehabilitation services worldwide

KEY RECOMMENDATIONS (Criteria: Class I and III and IIa A or B, IIbA recommendations only from best Guidelines reviewed based on COUNCIL Criteria)	Source	level of evidence/ GRADE	Resources required for implementation	Barriers and Facilitators for implementation	Pragmatic solutions and recommendation for contextualization and implementation through WSO implementation ecosystem on Stroke
ORGANIZATION OF REHABILITATION SERVICE					
Organized community-based and coordinated interprofessional rehabilitation care is recommended in the outpatient or home-based settings. Home-based rehabilitation may be considered as a preferred model for delivering rehabilitation in the community. Where home rehabilitation is unavailable, stroke patients requiring rehabilitation should receive centre-based care. People with stroke living in care homes should be offered assessment and treatment from community stroke rehabilitation services to identify activities and adaptations that might improve quality of life.	AHA ESAP Au UK	IC Weak Nil LoE: 5 QoE: very low SoR: 0	Rehabilitation personnel e.g., rehabilitation doctor/physician/neurologist; physiotherapist; occupational therapist; speech and language and dysphagia therapist; clinical psychologist; nurse; etc.	Inadequate number of rehabilitation personnel. Task-shifting and task-sharing with caregivers	WSO implementation ecosystem on Stroke commissioners to advocate for the training of rehabilitation personnel who can offer domiciliary services
It is recommended that early rehabilitation for hospitalized stroke patients be provided in environments with organized, interprofessional stroke care.	AHA ESAP	I A	Multidisciplinary rehabilitation facilities with rehabilitation doctor/physician/neurologist; physiotherapist; occupational therapist; speech and language and dysphagia therapist; clinical psychologist; nurse; etc.	Major barriers to be surmounted include lack of awareness and low demand, absence of/or inadequate number of rehabilitation professionals (need to establish training institutions/program to produce adequate number of professionals); need to adapt evidence-based practice recommendations to regional capacities (need to establish regional protocols / clinical pathways); need to finance rehabilitation services to make them accessible and available to all stroke patients	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services to all eligible stroke patients in their countries and regions.
All domains, including the body functions and structures (impairment), the activity and participation as well as the environmental factors domain of the ICF, can be used as a common language for professionals when setting goals in a semi-structured, 'guided' manner. Using the main ICF activity and participation domain as broad goal categories will prevent the missing of important goal areas, such as, interactions and relations and social and civil life.	WFNR	LoE: 5 QoE: very low SoR: 0			
Duration of complex interdisciplinary rehabilitation: It should be continued for a reasonable time to ensure that a potential for gradual recovery has a chance to evolve under specialized treatment and might be repeated at later stages to re-evaluate the potential for recovery.	WFNR	LoE: 5 QoE: very low [expert opinion] SoR: B+			

Comprehensive discharge care plans that address the specific needs of the stroke survivor should be developed in conjunction with the stroke survivor and carer prior to discharge.	Au	Strong recommendation	Adequate number of rehabilitation professionals to establish training institutions/program to produce adequate number of professionals	Limited number of rehabilitation professionals (need to establish training institutions/program to produce adequate number of professionals)	Need to finance rehabilitation services to make them accessible and available to all stroke patients
It is recommended that all individuals with stroke discharged to independent community living from post-acute rehabilitation or SNFs receive ADL and IADL assessment directly related to their discharge living setting, patient and family.	AHA	I B	Adequate number of post-acute rehabilitation centres	Limited number of post-acute rehabilitation centres	Need to finance post-acute rehabilitation centres
A functional assessment by a clinician with expertise in rehabilitation is recommended for patients with an acute stroke with residual functional deficits.	AHA	I C	Adequate number of rehabilitation professionals to establish training institutions/program to produce adequate number of professionals	Limited number of rehabilitation professionals (need to establish training institutions/program to produce adequate number of professionals)	Need to finance rehabilitation services to make them accessible and available to all stroke patients
Determination of post-acute rehabilitation needs should be based on assessments of residual neurological deficits; activity limitations; cognitive, communicative, and psychological status; swallowing ability; determination of previous functional ability and medical comorbidities; level of family/caregiver support; capacity of family/ caregiver to meet the care needs of the stroke survivor; likelihood of returning to community living; and ability to participate in rehabilitation.	AHA	I C	Multidisciplinary rehabilitation facilities with rehabilitation doctor/physician/neurologist; physiotherapist; occupational therapist; speech and language and dysphagia therapist; clinical psychologist; occupational therapist nurse; etc.	Major barriers to be surmounted include lack of awareness and low demand, absence of/or inadequate number of rehabilitation professionals (need to establish training institutions/program to produce adequate number of professionals); need to finance rehabilitation services to make them accessible and available to all stroke patients	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services in a variety of settings to all eligible stroke patients in their countries and regions. Early supported discharge should only be practiced if there is a coordinated community /family-based care and other comorbidities have been controlled such that there is no reason to keep the patient on admission
It is reasonable that individuals with stroke discharged from acute and post-acute hospitals/ centers receive formal follow-up on their ADL and IADL status, communication abilities, and functional mobility within 30 days of discharge.	AHA	IIa B	Multidisciplinary rehabilitation facilities with rehabilitation doctor/physician/neurologist; physiotherapist; occupational therapist; speech and language and dysphagia therapist; clinical psychologist; occupational therapist	Major barriers to be surmounted include lack of awareness and low demand, absence of/or inadequate number of rehabilitation professionals (need to establish training institutions/program to produce adequate number of professionals); need to adapt evidence-based practice recommendations to regional	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services in a variety of settings to all eligible stroke patients in their countries and regions.

				capacities (need to establish regional protocols / clinical pathways); need to finance rehabilitation services to make them accessible and available to all stroke patients	Early supported discharge should only be practiced if there is a coordinated community /family-based care and other co-morbidities have been controlled such that there is no reason to keep the patient on admission
Early supported discharge in which services are provided at home by a mobile well-resourced coordinated rehabilitation team, should be seen as a part of the stroke treatment pathway for patients with mild or moderate stroke symptoms. Where appropriate stroke services are available, early supported discharge services should be offered to stroke patients with mild to moderate disability. Early supported discharge services are an acceptable form of rehabilitation for a select group of patients when available and provided by a well-resourced, coordinated specialized interprofessional team	AHA (Fearon et al) ESAP Au Ca	I A Strong Evidence Level A.	Rehabilitation personnel e.g., rehabilitation doctor/physician/neurologist; physiotherapist; speech and language and dysphagia therapist; clinical psychologist; nurse; etc.	Inadequate number of rehabilitation personnel. Task-shifting and task-sharing with caregivers	WSO implementation ecosystem on Stroke commissioners to advocate for the training of rehabilitation personnel who can offer domiciliary services
It is recommended that stroke survivors receive rehabilitation at an intensity commensurate with anticipated benefit and tolerance. It has been demonstrated that increasing the intensity of therapy (in terms of more hours of exercise) for patients with a stroke, compared to less intensive exercising, results in more rapid recovery of selective movements, comfortable walking speed, maximum walking speed, walking distance, muscle tone, sitting and standing balance, performance of basic activities of daily living, and severity of depression and anxiety. Studied for early, late and chronic rehabilitation. Patients should receive rehabilitation therapies of appropriate intensity and duration, individually designed to meet their needs for optimal recovery and tolerance levels. People with stroke should accumulate at least 45 minutes of each appropriate therapy every day, at a frequency that enables them to meet their rehabilitation goals, and for as long as they are willing and capable of participating and showing measurable benefit from treatment.	AHA ESAP Ne Ca UK	I B (Level 1) (Evidence Level A). UK evidence level not stated	Multidisciplinary rehabilitation facilities with rehabilitation doctor/physician/neurologist; physiotherapist; occupational therapist; speech and language and dysphagia therapist; clinical psychologist; nurse; etc.	Major barriers to be surmounted include lack of awareness and low demand, absence of/or inadequate number of rehabilitation professionals (need to establish training institutions/program to produce adequate number of professionals); need to adapt evidence-based practice recommendations to regional capacities (need to establish regional protocols / clinical pathways); need to finance rehabilitation services to make them accessible and available to all stroke patients	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services to all eligible stroke patients in their countries and regions.
Communication assessment should consist of interview, conversation, observation, standardized tests, or non-standardized items; assess speech, language, cognitive communication, pragmatics, reading, and writing; identify communicative strengths and weaknesses; and identify helpful compensatory strategies	AHA	I B	Multidisciplinary approach with clinical neurologist, physiotherapist, occupational therapist, speech and language therapist, clinical psychologist	Limited number of rehabilitation professionals (need to establish training institutions/program to produce adequate number of professionals)	Need to finance multidisciplinary rehabilitation services to make them accessible and available to all stroke patients
Telerehabilitation is reasonable when face-to-face assessment is impossible or impractical	AHA	IIa A	Availability of tele-rehab system with hub and spoke model	Limited number of organized programs for tele-rehabilitation	Sponsoring tele-rehabilitation facilities
High-dose, very early mobilization within 24 hours of stroke onset can reduce the odds of a favourable outcome at 3 months and is NOT recommended	AHA Au	III A Strong	Appropriate trained rehabilitation staff	Same as above	Same as above

Patients with difficulty moving early after stroke who are medically stable should be offered frequent, short daily mobilizations (sitting out of bed, standing or walking) by appropriately trained staff with access to appropriate equipment, typically beginning between 24 and 48 hours of stroke onset. Mobilization within 24 hours of onset should only be for patients who require little or no assistance to mobilize	UK	Nil	(physiotherapist) with appropriate equipment		
Management of secondary complications resulting from primary impairments should commence in the acute phase, as well as being considered during sub-acute and long-term care. This includes prevention, early detection, and reduction strategies	Au		See below	See below	See below
Neurological weaning and rehabilitation centres: Prolonged weaning in stroke patients requires a special setting which can best be provided in neurological weaning and rehabilitation centres. Through the integrated possibilities of an adequate weaning process and a neurologically oriented multi-professional rehabilitation both successful weaning and the goal of the best possible interaction may simultaneously be achieved	WFNR	LoE: 2c QoE: low SoR: B+ [clinical reasoning]			
Weaning strategies: For prolonged weaning of stroke patients, strategies with progressively expanded spontaneous breathing phases can be used, taking into account the underlying pathology and a constant re-evaluation of patient response. In cases of disturbances of neuromuscular transmission, additional pressure support during the spontaneous breathing phases can be useful. Weaning in patients with central respiratory dysregulation disorders should be individualized, taking into account the underlying injury and also regular adjustments according to patient response					
Weaning and rehabilitation: Weaning in stroke patients ought to include (early) rehabilitation of various concomitant aspects of care to achieve best possible patient participation	WFNR	LoE: 5 QoE: very low SoR: A+ [clinical reasoning]			
Weaning protocols: Weaning protocols can be used during the weaning process of long-term mechanically ventilated stroke patients	WFNR	LoE: 5 QoE: very low SoR: 0			
Weaning and success criterion: Patients undergoing early neurological-neurosurgical rehabilitation are considered to have been successfully weaned if they manage at least 48 h without any mechanical ventilation	WFNR	LoE: 5 QoE: very low SoR: B+ [clinical reasoning]			
SKIN					
During hospitalization and inpatient rehabilitation, regular skin assessments are recommended with objective scales of risk such as the Braden scale.	AHA	I C	Nurse/ physician/care giver trained to inspect skin	Training of healthcare providers and caregivers	Include in routine assessments of stroke patients
It is recommended to minimize or eliminate skin friction, to minimize skin pressure, to provide appropriate support surfaces, to avoid excessive moisture, and to maintain adequate nutrition and	AHA	I C	Trained personnel, specialized mattresses (waterbed, air mattress)	Barriers include availability and affordability of specialized	Training of personnel. Provision of specialized mattresses.

hydration to prevent skin breakdown. Regular turning, good skin hygiene, and use of specialized mattresses, wheelchair cushions, and seating are recommended until mobility returns				mattresses, availability of trained personnel	
Patients, staff, and caregivers should be educated about the prevention of skin breakdown	AHA	I C	Trained personnel /training materials	Trained personnel	Educate patients, staff and caregivers on the prevention of skin breakdown.
In ischaemic stroke, prophylactic-dose subcutaneous heparin (UFH or LMWH) should be used for the duration of the acute and rehabilitation hospital stay or until the stroke survivor regains mobility	AHA	I A	Subcutaneous heparin	Availability of subcutaneous heparin	Provision and administration of sc Heparin for DVT prophylaxis in patients with ischaemic stroke
In ICH, it may be reasonable to use intermittent pneumatic compression devices over no prophylaxis	AHA	IIb C	intermittent pneumatic compression devices	Availability and affordability of intermittent pneumatic compression devices	Provision of intermittent pneumatic compression devices for ICH patients
In ICH, it is not useful to use elastic compression stockings	AHA	III C	training	training	training
In ischaemic stroke, it is not useful to use elastic compression stockings	AHA	III B	training	training	training
URINARY TRACT					
A history of urological issues before stroke should be obtained Assessment of urinary retention through bladder scanning or intermittent catheterizations after voiding while recording volumes is recommended for patients with urinary incontinence or retention Stroke unit staff should be trained in the use of standardized assessment and management protocols for urinary and faecal incontinence and constipation in people with stroke Assessment of cognitive awareness of need to void or having voided is reasonable	AHA UK AHA	I B IIa B	training	training	training
Removal of the Foley catheter (if any) within 24 hours after admission for acute stroke is recommended People with stroke should NOT have an indwelling (urethral) catheter inserted unless indicated to relieve urinary retention or when fluid balance is critical People with stroke who have continued loss of bladder and/or bowel control 2 weeks after onset should be reassessed to identify the cause of incontinence and be involved in deriving a treatment plan (with their family/carers if appropriate). The treatment plan should include: – treatment of any identified cause of incontinence – training for the person with stroke and/or their family/carers in the management of incontinence – referral for specialist treatments and behavioural adaptations if the person is able to participate. – adequate arrangements for the continued supply of continence aids and services. People with stroke with continued loss of urinary continence should be offered behavioural interventions and adaptations such as: – timed toileting – prompted voiding	AHA UK	I B Nil	Training, medications, continence aids catheter	Training, availability of affordable continence aids, catheter, medications	Training of healthcare providers and caregivers, provision of medications and continence aids

– review of caffeine intake – bladder retraining – pelvic floor exercises – external equipment prior to considering pharmaceutical and long-term catheter options					
People with stroke with constipation should be offered: – advice on diet, fluid intake and exercise – a regulated routine of toileting – a prescribed drug review to minimize use of constipating drugs – oral laxatives – a structured bowel management program which includes nurse-led bowel care interventions – education and information for the person with stroke and their family/carers – rectal laxatives if severe problems persist People with continued continence problems on transfer of care from hospital should receive follow-up with specialist continence services in the community	UK	Nil	Training, laxatives	Training and availability of laxatives and medications	Training of healthcare providers and caregivers, provision of medications and continence aids
PAIN					
Patient and family education (i.e., range of motion, positioning) is recommended for shoulder pain and shoulder care after stroke, particularly before discharge or transitions in care	AHA	I C	Education	Education	Training of care providers to educate patients/family members
The use of overhead pulley exercises is not recommended	AHA	III C	Training	Training	Training
The diagnosis of central poststroke pain should be based on established diagnostic criteria after other causes of pain have been excluded	AHA	I C	Training	Training	Training
The choice of pharmacological agent for the treatment of central poststroke pain should be individualized to the patient's needs and response to therapy and any side effects	AHA	I C	Multidisciplinary approach with clinical neurologist, clinical pharmacist, and pain management team	Major barriers to be surmounted include absence of/or inadequate number of clinical pharmacist and pain management team available to all stroke patients	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services in a variety of settings to all eligible stroke patients in their countries and regions. In addition to financing co-ordinated programs between Neurologists, clinical pharmacists, and pain management team
Amitriptyline and lamotrigine are reasonable first-line pharmacological treatments People with central post-stroke pain should be initially treated with amitriptyline, gabapentin or pregabalin: – amitriptyline starting at 10 mg per day, with gradual titration as tolerated, but no higher than 75 mg per day (higher doses could be considered in consultation with a specialist pain service) – gabapentin starting at 300 mg twice daily with titration as tolerated to a maximum of 3.6 g per day	AHA UK	IIa B Nil	Multidisciplinary approach with clinical neurologist, clinical pharmacist, and pain management team	Major barriers to be surmounted include absence of/or inadequate number of clinical pharmacist and pain management team available to all stroke patients	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services in a variety

– pregabalin starting at 150 mg per day (in two divided doses; a lower starting dose may be appropriate for some people), with titration as tolerated but no higher than 600 mg per day in two divided doses B People with central post-stroke pain who do not achieve satisfactory pain reduction with initial pharmacological treatment at the maximum tolerated dose should be considered for treatment with another drug of or in combination with the original drug: – if initial treatment was with amitriptyline switch to or combine with pregabalin – if initial treatment was with gabapentin switch to pregabalin – if initial treatment was with pregabalin switch to or combine with amitriptyline					of settings to all eligible stroke patients in their countries and regions. In addition to financing co-ordinated programs between Neurologists, clinical pharmacists, and pain management team
C People with central post-stroke pain should be regularly reviewed including physical and psychological wellbeing, adverse effects, the impact on lifestyle, sleep, activities and participation, and the continued need for pharmacological treatment. If there is sufficient improvement, treatment should be continued and gradual reductions in the dose over time should be considered if improvement is sustained.	UK	Nil	Multidisciplinary approach with clinical neurologist, clinical pharmacist, and pain management team	Major barriers to be surmounted include absence of/or inadequate number of clinical pharmacist and pain management team available to all stroke patients	Financing co-ordinated programs between neurologists, clinical pharmacists, and pain management team
People with musculoskeletal pain after stroke should be assessed to ensure that movement, posture and moving and handling techniques are optimized to reduce pain B People who continue to experience musculoskeletal pain should be offered pharmacological treatment with simple analgesic drugs. Paracetamol, topical non-steroidal anti-inflammatory drugs (NSAIDs) or transcutaneous electrical nerve stimulation (TENS) should be offered before considering the addition of opioid analgesics	UK	Nil	Multidisciplinary approach with physiotherapist, clinical neurologist, clinical pharmacist, and pain management team	Major barriers to be surmounted include inadequate number of rehabilitation professionals, clinical pharmacist and pain management team	Financing coordinated programs between neurologists, clinical pharmacists, and pain management team
TENS has not been established as an effective treatment	AHA	III B	Training	Training	Training
Deep brain stimulation has not been established as an effective treatment	AHA	III	Training	Training	Training
FALLS					
It is recommended that individuals with stroke discharged to the community participate in exercise programs with balance training to reduce falls	AHA	I B	Rehabilitation facilities with trained professionals for balance exercise	Limited number of trained professionals	Free online training videos in different languages on goal setting, and caregiver training
It is recommended that individuals with stroke be provided a formal fall prevention program during hospitalization People with stroke should be offered falls risk assessment and management as part of their stroke rehabilitation, including training for them and their family/carers in how to get up after a fall People with stroke should be offered an assessment of fear of falling as part of their falls risk assessment People at high risk of falls after stroke should be offered a standardized assessment of fragility fracture risk as part of their stroke rehabilitation People with stroke with symptoms of vitamin D deficiency, or those who are considered to be at high risk (e.g., housebound) should be offered calcium and vitamin D supplements People at high risk of falls after stroke should be advised to participate in physical activity/exercise which incorporates balance and co-ordination at least twice per week	AHA UK	I A Nil	In hospital rehabilitation programs with balance and falls risk assessment	Limited number of organized programs with assessment of balance and risk falls	Support for workshops, production of free online training materials
Any patient who develops a seizure should be treated with standard management approaches, including a search for reversible causes of seizure in addition to potential use of antiepileptic drugs	AHA	I C	Availability of well-trained neurologists with experience in epilepsy management	Limited number of trained neurologists	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor

					strategic action plan with all stakeholders to ensure availability of trained neurologists
DEPRESSION					
Administration of a structured depression inventory such as the Patient Health Questionnaire-2 is recommended to routinely screen for poststroke depression	AHA	I B	Availability of well-trained psychiatrists	Limited number of trained psychiatrists	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of trained psychiatrists
Techniques to support people with mild symptoms of depression A range of techniques to support people with mild symptoms of depression can be considered (e.g., behavioral therapy, psychosocial support, and problem-solving)	WFNR	LoE: 2a QoE: very low to low SoR: 0			
Patient education about stroke is recommended Patients should be provided with information, advice, and the opportunity to talk about the impact of the illness on their lives All stroke survivors and their families/carers should be offered information tailored to meet their individual needs using relevant language and communication format. Information should be provided at different stages in the recovery process	AHA Au	I B Strong	In-hospital patient education programs, media awareness campaign	Major barriers to be surmounted include lack of awareness and low demand	Support for awareness campaign, and free online training materials
Patients diagnosed with poststroke depression should be treated with antidepressants in the absence of contraindications and closely monitored to verify effectiveness People with stroke who persistently cry or laugh in unexpected situations or are upset by their fluctuating emotional state should be assessed by a specialist member of the multidisciplinary team trained in the assessment of emotionalism People with severe or persistent emotionalism after stroke should be given antidepressant medication, monitoring effectiveness by the frequency of crying. They should be monitored for adverse effects and treated for at least four months beyond initial recovery. If the person's emotionalism has not improved after 2-4 weeks, medication adherence should be checked before considering a dose increase or a change to another antidepressant	AHA Au UK	I B Strong Nil	Multidisciplinary approach with neurologist, clinical psychologist. clinical pharmacist, and psychiatrist	Major barriers to be surmounted include absence of/or inadequate number of neurologists, psychotherapist. clinical pharmacist, and psychiatrist available to all stroke patients	Financing coordinated programs between neurologist, psychotherapist. clinical pharmacist, and psychiatrist management team
No recommendation for the use of any particular class of antidepressants is made. SSRIs are commonly used and generally well tolerated in this patient population	AHA Au	III A Strong	Training	Training	Training
In the first months, post-stroke antidepressant pharmacotherapy is only recommended if the process of rehabilitation is hindered by emotional problems. Increasing motivation for and participation in rehabilitation is the target for treatment. Selective serotonin reuptake inhibitors, SSRIs should be considered when depressive complaints or emotionalism are long lasting and become chronic while adverse effects should be monitored continuously	WFNR	LoE: 1a QoE: moderate SoR: B+			
People with stroke with one mood disorder (e.g., depression) should be assessed for others (e.g., anxiety) B People with or at risk of depression or anxiety after stroke should be offered brief psychological interventions such as motivational interviewing or problem-solving therapy (adapted, if necessary,	UK	Nil	Multidisciplinary approach with neurologist, clinical psychologist, and psychiatrist team	Major barriers to be surmounted include absence of/or inadequate number of neurologists, clinical	Financing coordinated programs between stroke physician / neurologist, clinical psychologist,

for use with people with aphasia or cognitive problems) before considering antidepressant medication C People with mild or moderate symptoms of psychological distress, depression or anxiety after stroke should be given information, support and advice and considered for one or more of the following interventions: – increased social interaction – increased exercise – other psychosocial interventions such as psychosocial education groups D People with aphasia and low mood after stroke should be considered for individual behavioural therapy e.g., from an assistant psychologist E People with depression or anxiety after stroke who are treated with antidepressant medication should be monitored for adverse effects and treated for at least four months beyond initial recovery. If the person's mood has not improved after 2-4 weeks, medication adherence should be checked before considering a dose increase or a change to another antidepressant F People with severe or persistent symptoms of emotional disturbance after stroke should receive specialist assessment and treatment from a clinical neuropsychologist/clinical psychologist G People with persistent moderate to severe emotional disturbance after stroke who have not responded to high intensity psychological intervention or pharmacological treatment should be considered for collaborative care. Their care should involve collaboration between the GP, primary and secondary physical health services and case management, with supervision from a senior mental health professional and should include long term follow-up People diagnosed with emotionalism after stroke should be appropriately distracted from the provoking stimulus when they show increased emotional behavior				psychologist, and psychiatrist available to all stroke patients	and psychiatrist management team
Problem-solving therapy and motivational interviewing can be considered to prevent depressive symptoms post-stroke	WFNR	LoE: 2b QoE: low SoR: 0			
MISCELLANEOUS					
It is recommended that all individuals with stroke be provided a formal assessment of their ADLs and IADLs, communication abilities, and functional mobility before discharge from acute care hospitalization and the findings be incorporated into the care transition and the discharge planning process People with stroke should be formally assessed for their safety and independence in all relevant personal activities of daily living by a clinician with the appropriate expertise, and the findings should be recorded using a standardized assessment tool People with limitations of personal activities of daily living after stroke should be referred to an occupational therapist with experience in neurological disability, be assessed within 72 hours of referral, and be offered treatment for identified problems (e.g., feeding, toileting) by the occupational therapist, who should also involve other members of the specialist multidisciplinary team People with stroke should be offered, as needed, specific treatments that include: – dressing practice for people with residual problems with dressing– as many opportunities as appropriate to practice self-care	AHA UK	I B Nil	Multidisciplinary rehabilitation facilities with rehab doctor/physician/neurologist; physiotherapist; speech and language and dysphagia therapist; clinical psychologist; occupational therapist nurse; etc.	Major barriers to be surmounted include lack of awareness and low demand, absence of/or inadequate number of rehabilitation professionals (need to establish training institutions/program to produce adequate number of professionals); need to adapt evidence-based practice recommendations to regional capacities (need to establish regional protocols / clinical pathways); need to finance rehabilitation services to make	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services in a variety of settings to all eligible stroke patients in their countries and regions. Early supported discharge should only be practiced if there is a coordinated community /family-based care; and other comorbidities have been controlled such that there is no

– assessment, provision and training in the use of equipment and adaptations that increase safe independence – training of family/carers in how to help the person with stroke People whose activities have been limited by stroke should be: – assessed by an occupational therapist with expertise in neurological disability – trained in how to achieve activities safely and be given as many opportunities to practise as reasonable under supervision, provided that the activities are potentially achievable – provided with and trained in how to use any adaptations or equipment needed to perform activities safely People with stroke who cannot undertake a necessary activity safely should be offered alternative means of achieving the goal to ensure safety and well-being People with difficulty executing tasks after stroke despite adequate limb movement should be assessed for the presence of apraxia using standardized measures B People with apraxia after stroke should: – have their profile of impaired and preserved abilities determined using a standardized approach – have the impairment and the impact on function explained to them, their family/carers, and the multidisciplinary team – be offered therapy and/or trained in compensatory techniques specific to the deficits identified, ideally in the context of a clinical trial				them accessible and available to all stroke patients	reason to keep the patient on admission
For stroke survivors in the acute, sub-acute or chronic phase post-stroke, acupuncture should NOT be used to improve AD	Au	Strong recommendation AGAINST	Training	Training	Training
Administration of amphetamines to improve ADL is NOT recommended	Au	Strong recommendation AGAINST	Training	Training	Training
CONSCIOUSNESS					
Amantadine for a course of amantadine treatment over a couple of weeks can be used in the beginning of the rehabilitation treatment of stroke survivors with DoC (VS-MCS) to promote recovery in the disability domain The evidence is too limited to guide clinical decision-making with respect to long-term use and discontinuation of amantadine, or the prescription of other drugs to treat DoC in stroke survivors	WFNR	LoE: 1b QoE: moderate SoR: 0 [indirectness of evidence]			
The evidence is too limited to guide clinical decision-making for therapies such as tilt therapy with integrated stepping device, repetitive transcranial magnetic stimulation, rTMS, or transcranial direct current stimulation, tDCS when used with the intention to treat DoC in stroke survivors. Their use is discouraged for routine clinical practice with the therapeutic goal to improve DoC in stroke survivors	WFNR	LoE: 4 to 1b QoE: very low to moderate SoR: B-			
The routine administration of standardized measures can be useful to document the severity of stroke and resulting disability, starting in the acute phase, and progressing over the course of recovery and rehabilitation.	AHA	IIa C	Adequate number of rehabilitation professionals to establish training institutions/program to produce adequate number of professionals	Limited number of rehabilitation professionals (need to establish training institutions/program to produce adequate number of professionals)	Need to finance rehabilitation services to make them accessible and available to all stroke patients

COGNITION					
Screening for cognitive deficits is recommended for all stroke patients before discharge home When screening reveals cognitive deficits, a more detailed neuropsychological evaluation to identify areas of cognitive strength and weakness may be beneficial Services for people with stroke should have a comprehensive approach to delivering psychological care that includes specialist clinical neuropsychology/clinical psychology input within the multi-disciplinary team People with stroke should be considered to have at least some cognitive impairment in the early phase. Routine screening should be undertaken to identify the person's level of functioning, using standardized measures People with communication impairment after stroke should receive a cognitive assessment using valid assessments in conjunction with a speech and language therapist. Specialist advice should be sought if there is uncertainty about the interpretation of cognitive test results Any person with stroke who is not progressing as expected in rehabilitation should receive a detailed assessment to determine whether cognitive impairments are responsible, with the results explained to the person, their family, and the multidisciplinary team People with acute cognitive problems after stroke whose care is being transferred from hospital should receive an assessment for any safety risks from persisting cognitive impairments. Risks should be communicated to their primary care team together with any mental capacity issues that might affect their decision-making People with stroke returning to cognitively demanding activities such as driving, or work should have their cognition fully assessed	AHA AHA UK	I B IIa C Nil	Multidisciplinary approach should include trained clinical psychologist experienced in cognitive assessment (neuropsychologist)	Limited number of trained neuropsychologists	Need to finance multidisciplinary rehabilitation including neuropsychologists
People with continuing cognitive difficulties after stroke should be considered for comprehensive interventions aimed at developing compensatory behaviours and learning adaptive skills People with severe or persistent cognitive problems after stroke should receive specialist assessment and treatment from a clinical neuropsychologist/clinical psychologist People with cognitive problems after stroke should receive appropriate adjustments to their multidisciplinary treatments to enable them to participate, and this should be regularly reviewed	UK	Nil	Multidisciplinary approach should include trained neuropsychologist experienced in cognitive assessment Multidisciplinary approach should include trained clinical psychologist experienced in cognitive assessment (neuropsychologist)	Limited number of trained neuropsychologists	Need to finance multidisciplinary rehabilitation including neuropsychologists
The specialist multidisciplinary team should be involved in making decisions about mental capacity, and should provide information and advice to the person with stroke (when appropriate) and their family/carers	UK	Nil	Multidisciplinary approach should include trained clinical psychologist experienced in	Limited number of trained neuropsychologists	Need to finance multidisciplinary rehabilitation including neuropsychologists

			cognitive assessment (neuropsychologist)		
Evaluation of stroke patients for sensory impairments, including touch, vision, and hearing, is probably indicated	AHA	IIa B	Availability of clinical neurologist and physiotherapist	Limited number clinical neurologist and physiotherapist	Need to finance multidisciplinary rehabilitation stroke program
People with stroke should be: – assessed for visual acuity whilst wearing the appropriate glasses to check their ability to read newspaper text and see distant objects clearly – examined for the presence of visual field deficit (e.g., hemianopia) and eye movement disorders (e.g., strabismus and motility deficit) People with altered vision, visual field defects or eye movement disorders after stroke should receive information, support, and advice from an orthoptist and/or an ophthalmologist People with visual loss due to retinal artery occlusion should be jointly managed by an ophthalmologist and a stroke physician	UK	Nil	Availability of clinical ophthalmologist for stroke patient	Limited number of clinical ophthalmologists	Need to finance coordinated program between neurologists and clinical ophthalmologists for stroke cases presenting with visual symptoms
It has been shown that visual search training was more effective than prism glasses and standard care (no training) in improving vision-related quality of life in patients with visual field deficits, VFDs. As a consequence, they should be used for treatment of VFD patients		LoE: 2a-1a QoE: low to moderate SoR: B+			
With an acquired deficit of light and/or dark adaptation of the visual system (not the eye!) tinted glasses may reduce the feelings of blinding, while additional light sources and the use of light dimmers are helpful to cope with dark vision. These treatments do not “heal” the original underlying disorder or light–dark adaptation, but they alleviate the behavioral consequences for the patients and can be used	WFNR	LoE: 4 QoE: very low SoR: 0			
Systematization of visual search strategies by cognitive instructions reduces omissions	WFNR	LoE: 4 - 2b QoE: low SoR: 0			
People with stroke should be screened for altered sensation and if present, assessed for sensory impairments using standardized measures People with sensory loss after stroke should be trained in how to avoid injury to the affected body parts	UK	Nil	Availability of clinical neurologist and physiotherapist	Limited number clinical neurologist and physiotherapist	Need to finance multidisciplinary rehabilitation stroke program
Recommendations: Nondrug therapies for cognitive impairment, including memory class level of evidence, enriched environments to increase engagement with cognitive activities are recommended People with stroke who report memory problems and those considered to have problems with learning and remembering should have their memory assessed using standardized measures B People with memory impairment after stroke causing difficulties with rehabilitation should: – have the impairment explained to them, their family/carers and the multidisciplinary team – be assessed for treatable or contributing factors (e.g., delirium, hypothyroidism) – have their profile of impaired and preserved memory abilities determined, including the impact of other cognitive deficits e.g., attention – have nursing and therapy sessions altered to capitalize on preserved abilities	AHA UK	I A Nil	Multidisciplinary approach should include trained clinical psychologist, neuropsychiatrist for assessment, advice, and monitoring for stroke cases with cognitive impairment	Limited number of trained clinical psychologist, neuropsychiatrist in cognitive and neurobehavioral assessment	Financing coordinated programs between neurologists, clinical psychologist, and neuropsychiatrist for stroke cases with cognitive impairment

– be trained in approaches that help them to encode, store and retrieve new information e.g., spaced retrieval (increasing time intervals between review of information) or deep encoding of material (emphasizing semantic features) – be trained in compensatory techniques to reduce their prospective memory problems (e.g., use of electronic reminders or written checklists) – receive therapy in an environment as similar as possible to their usual environment					
Use of cognitive rehabilitation to improve attention, memory, visual neglect, and executive functioning is reasonable. It has been demonstrated that attention training using compensation strategies has a favorable effect on the attention span of patients whose stroke occurred 6 weeks ago Cognitive rehabilitation aimed at memory deficits It has been demonstrated that memory strategies using internal and external strategies have a favorable effect on patients with a stroke in terms of learning to compensate for mild memory deficits (Level 1). People who appear easily distracted or unable to concentrate after stroke should have their attentional abilities assessed using standardized measures People with impaired attention after stroke should have cognitive demands reduced by: – having shorter treatment sessions – taking planned rests – reducing background distractions – avoiding activities when tired People with impaired attention after stroke should: – have the impairment explained to them, their family/carers and the multidisciplinary team – be offered an attentional intervention (e.g., time pressure management, attention process training, environmental manipulation), ideally in the context of a clinical trial – be given as many opportunities to practice their activities as reasonable under supervision	AHA Ne UK	IIa B Level 1 Nil	Multidisciplinary approach should include trained neuropsychologist or physician with training in cognitive neurology for assessment, advice, and monitoring for stroke cases with cognitive impairment	Limited number of trained neuropsychologist or physician with training in cognitive neurology for cognitive and neurobehavioral assessment	Financing coordinated programs between clinical neurologists and neuropsychologist for stroke cases with cognitive impairment
People who appear to have perceptual difficulties after stroke should have a perceptual assessment using standardized measures People with agnosia after stroke should: – have the impairment explained to them, their family/carers and the multidisciplinary team – have their environment assessed and adapted to reduce potential risks and promote independence – be offered a perceptual intervention, such as functional training, sensory stimulation, strategy training and/or task repetition, ideally in the context of a clinical tria.	UK	Nil	Multidisciplinary approach should include trained neuropsychologist or physician with training in cognitive neurology for assessment, advice and monitoring for stroke cases with cognitive impairment	Limited number of trained neuropsychologist or physician with training in cognitive neurology for cognitive and neurobehavioral assessment	Financing coordinated programs between clinical neurologists and neuropsychologist for stroke cases with cognitive impairment
Use of cognitive training strategies that consider practice, compensation, and adaptive techniques for increasing independence is reasonable	AHA	IIa B	Multidisciplinary approach should include trained neuropsychologist or physician with training in cognitive neurology for assessment, advice and monitoring for stroke cases with cognitive impairment	Limited number of trained neuropsychologist or physician with training in cognitive neurology for cognitive and neurobehavioral assessment	Financing coordinated programs between clinical neurologists and neuropsychologist for stroke cases with cognitive impairment

Compensatory strategies may be considered to improve memory functions, including the use of internalized strategies (e.g., visual imagery, semantic organization, spaced practice) and external memory assistive technology (e.g., notebooks, paging systems, computers, other prompting devices)	AHA	IIb A	Multidisciplinary approach should include trained neuropsychologist or physician with training in cognitive neurology for assessment, advice and monitoring for stroke cases with cognitive impairment	Limited number of trained neuropsychologist or physician with training in cognitive neurology for cognitive and neurobehavioral assessment	Financing coordinated programs between clinical neurologists and neuropsychologist for stroke cases with cognitive impairment
Interventions for cognitive-communication disorders are reasonable to consider if they are individually tailored and target: The overt communication deficit affecting prosody, comprehension, expression of discourse, and pragmatics. The cognitive deficits that accompany or underlie the communication deficit, including attention, memory, and executive	AHA	IIa B	Multidisciplinary approach should include trained neuropsychologist or physician with training in cognitive neurology for assessment, advice and monitoring for stroke cases with cognitive impairment	Limited number of trained neuropsychologist or physician with training in cognitive neurology for cognitive and neurobehavioral assessment	Financing coordinated programs between clinical neurologists and neuropsychologist for stroke cases with cognitive impairment
It has been demonstrated that visual scanning training has a favorable effect on the attention for the neglected side of patients with a stroke in the right hemisphere. Studied for ER (?), LR (?) and RC People with stroke affecting the non-dominant cerebral hemisphere should be considered at risk of impaired awareness on the contralateral side and should be assessed for this using standardized measures When assessing problems with spatial awareness in people with stroke, clinicians should use a standardized test battery in preference to a single subtest, and the effect on functional tasks such as dressing, and mobility should be included People with impaired awareness to one side after stroke should: – have the impairment explained to them, their family/carers and the multidisciplinary team – be trained in compensatory strategies to reduce the impact on their activities – be given cues to draw attention to the affected side during therapy and nursing activities – be monitored to ensure that they do not eat too little through missing food on one side of the plate – be offered interventions aimed at reducing the functional impact of the reduced awareness (e.g., visual scanning training, limb activation, sensory stimulation, eye patching, prism wearing, prism adaptation training, mirror therapy, galvanic vestibular stimulation, transcranial magnetic stimulation), ideally in the context of a clinical trial	Ne UK	Level 1 Nil	Multidisciplinary approach should include trained neuropsychiatrist for assessment, advice and monitoring for stroke cases with cognitive impairment	Major barriers to be surmounted include lack of awareness and low demand, absence of/or inadequate number of professionals	Financing training program, workshops and online materials for healthcare provider
DYSPHASIA SCREENING, MANAGEMENT, AND NUTRITIONAL SUPPORT					
Early dysphagia screening is recommended for acute stroke patients to identify dysphagia or aspiration, which can lead to pneumonia, malnutrition, dehydration, and other complications	AHA Au	I B Strong	Multidisciplinary approach should include trained speech and swallowing therapist	Limited number of trained speech and swallowing therapist	Financing training program, workshops and online materials for healthcare provider
Dysphagia screening: Dysphagia screening ought to be administered by the trained healthcare provider early after stroke onset before starting oral feeding to prevent pneumonia and other adverse events such as malnutrition, dehydration, and to reduce mortality	WFNR	LoE: 1 QoE: moderate SoR: A+ [clinical reasoning]			

Dysphagia Screening tools: One of the dysphagia screening tools that shows acceptable reliability, higher sensitivity, and negative predictive value, which consists of items such as alertness assessment, dry swallowing test, and direct swallowing test with water or semisolid and solid foods, should be used	WFNR	LoE: 1 QoE: moderate SoR: B+			
Dysphagia screening is reasonable to be administered by a speech-language pathologist /therapist or other trained healthcare provider	AHA	IIa C	Multidisciplinary approach should include trained speech and swallowing therapist	Limited number of trained speech and swallowing therapist	Financing training program, workshops and online materials for healthcare provider
Assessment of swallowing before the patient begins eating, drinking, or receiving oral medications is recommended	AHA	I B	Multidisciplinary approach should include trained speech and swallowing therapist	Limited number of trained speech and swallowing therapist	Financing training program, workshops and online materials for healthcare provider
An instrumental evaluation is probably indicated for those patients suspected of aspiration to verify the presence/absence of aspiration and to determine the physiological reasons for the dysphagia to guide the treatment plan	AHA	IIa B	Implementation of a dysphagia screening program for all stroke cases	Major barriers to be surmounted include lack of awareness and low demand, absence of/or inadequate number of professionals	Financing training program, workshops and online materials for healthcare provider
Selection of instrumental study (fibreoptic endoscopic evaluation of swallowing, video-fluoroscopy, fibreoptic endoscopic evaluation of swallowing with sensory testing) may be based on availability or other considerations	AHA	IIb C	Implementation of instrumental evaluation of dysphagia for stroke cases with positive screening test	Limited investigational tools and training programs	Financing for instrumental tools and training program, workshops and online materials
Instrumental assessment of dysphagia: Instrumental assessments such as video-fluoroscopic swallowing study, VFSS or fibreoptic endoscopic evaluation of swallowing, FEES ought to be performed to verify the aspiration and to set the appropriate dysphagia management plan in stroke patients who showed the risk for pharyngeal dysphagia or aspiration in the initial or ongoing swallowing screens	WFNR	LoE: 1 QoE: moderate SoR: A+ [clinical reasoning]			
Oral hygiene care should be implemented to reduce the risk of pneumonia after stroke	WFNR	LoE: 2 QoE: moderate SoR: B+			
Oral hygiene protocols should be implemented to reduce the risk of aspiration pneumonia after stroke All stroke patients, particularly those with swallowing difficulties, should have assistance and/or education to maintain good oral and dental (including dentures) hygiene Staff and carers of stroke patients (in hospital, in residential care and home settings) should be trained in assessment and management of oral hygiene People with stroke, especially those who have difficulty swallowing or are tube fed, should have mouth care at least 3 times a day including: – brushing of teeth and cleaning of gums with a suitable cleaning agent (toothpaste and/or chlorhexidine dental gel), for which an electric toothbrush should be considered – removal of excess secretions – application of lip balm People with stroke who have dentures should have their dentures: – put in during the day – cleaned regularly using a toothbrush, toothpaste and/or chlorhexidine dental gel	AHA Au UK	I B Strong Nil	Implementation of oral hygiene protocols for all stroke cases presented with swallowing problems	Major barriers to be surmounted include lack of awareness and low demand, absence of/or inadequate number of professionals	Training program, workshops and online materials for healthcare providers and caregivers

– checked and replaced if ill-fitting, damaged or lost People in hospital or living in a care home after stroke should receive mouth care from staff who have been trained in: – assessment of oral hygiene – selection and use of appropriate oral hygiene equipment and cleaning agents – provision of oral care routines – awareness and recognition of swallowing difficulties People with stroke and their family/carers should receive information and training in mouth care and maintaining good oral hygiene before transfer of their care from hospital					
For stroke survivors with swallowing difficulties, behavioral approaches such as swallowing exercises, environmental modifications, safe swallowing advice, and appropriate dietary modifications should be used early People with difficulties self-feeding after stroke should be assessed and provided with the appropriate equipment and assistance (including physical help and verbal encouragement) to promote independent and safe feeding	Au UK	Strong Nil	Multidisciplinary approach should include trained speech and swallowing therapist	Limited number of trained speech and swallowing therapist	Financing for instrumental tools and training program, workshops and online materials
Enteral feedings (tube feedings) should be initiated within 7 days after stroke for patients who cannot safely swallow	AHA	I A	Implementation of a dysphagia screening program for all stroke cases	Major barriers to be surmounted include lack of awareness and low demand, absence of/or inadequate number of professionals	Financing training program, workshops and online materials for healthcare provider
Enteral tube feeding: Early enteral tube feeding should be implemented in stroke patients with dysphagia who cannot swallow safely and intake sufficient nutrition orally	WFNR	LoE: 1 QoE: moderate SoR: B+			
Early gastrostomy within 4 weeks after stroke does not have to be prioritized over nasogastric tube feeding, unless there is a mandatory reason for percutaneous gastrostomy	WFNR	LoE: 1 QoE: low SoR: 0			
Nasogastric tube feeding should be used for short term (2–3 weeks) nutritional support for patients who cannot swallow safely	AHA	I B	Implementation of a dysphagia screening program for all stroke cases	Major barriers to be surmounted include lack of awareness and low demand, absence of/or inadequate number of professionals	Financing training program, workshops and online materials for healthcare provider
Percutaneous gastrostomy tubes should be placed in patients with chronic inability to swallow safely People with stroke should be considered for gastrostomy feeding if they: – need but are unable to tolerate nasogastric tube feeding – are unable to swallow adequate food and fluids orally by four weeks from the onset of stroke – are at high long-term risk of malnutrition	AHA UK WFNR	I B Nil	Implementation of instrumental evaluation of dysphagia for stroke cases with positive screening test	Limited investigational tools and training programs	Financing for instrumental tools and training program, workshops and online materials

Nutritional supplements are reasonable to consider for patients who are malnourished or at risk of malnourishment People with stroke who require food or fluid of a modified consistency should: – be referred to a dietitian for specialist nutritional assessment, advice and monitoring – have the texture of modified food or fluids prescribed using nationally agreed descriptors People with stroke discharged from specialist care services with continuing problems meeting their nutritional needs should have their dietary intake and nutritional status monitored regularly People with stroke receiving end-of-life (palliative) care should not have burdensome restrictions imposed on oral food and/or fluid intake if those restrictions would exacerbate suffering	AHA UK	IIa B Nil	Multidisciplinary approach should include trained dietitian for specialist nutritional assessment, advice and monitoring for stroke cases with prolonged swallowing difficulties	Limited number of dietitians for specialist nutritional assessment	Financing coordinated programs between clinical neurologists and dietitians for stroke cases with prolonged swallowing problems
Behavioural interventions for dysphagia treatment program including behavioral interventions should be provided for the dysphagia patients after stroke to prevent dysphagia-related complications and to recover the swallowing	WFNR	LoE: 1 QoE: moderate SoR: B+			
Neuromuscular electrical stimulation, NMES, can be used to improve the swallowing function in patients with dysphagia after stroke, combined with a traditional swallowing treatment program including behavioral interventions	WFNR	LoE: 1 QoE: low SoR: 0			
Acupuncture for dysphagia treatment: Acupuncture can be considered to treat post-stroke dysphagia	WFNR	LoE: 1 QoE: low SoR: 0			
rTMS for post stroke dysphagia: TMS can be considered to treat post-stroke dysphagia by the clinical expert in this field as an additional treatment modality to the traditional swallowing treatment, especially within 3 months post-stroke	WFNR	LoE: 1 QoE: low SoR: 0			
Non-invasive ventilation: Non-invasive ventilation ought not to be used in patients with neurogenic dysphagia or prolonged reduced vigilance and a high risk of aspiration. In these patients, a blocked-off tracheostomy tube should remain as a portal for ventilator access until there is no danger of macro-aspiration	WFNR	LoE: 5 QoE: very low SoR: A- [clinical reasoning]			
Drug therapy, NMES, pharyngeal electrical stimulation, physical stimulation, tDCS, and transcranial magnetic stimulation are of uncertain benefit and not currently recommended	AHA	III A	Training	Training	Training
Anodal tDCS over the left dorsolateral prefrontal cortex to improve language-based complex attention (working memory) remains experimental	AHA	III B	Training	Training	Training
Active, contralesionally smooth pursuit eye movements reduce multimodal neglect (by reactivation of ipsi- and contralesional parietal cortices) and should be used to treat neglect	WFNR	LoE: 2b, 1b QoE: moderate SoR: B			
Repetitive neck muscle vibration, NMV realigns subjective straight-ahead direction (probably by activation of right perisylvian and insular cortices) and can be used to treat neglect	WFNR	LoE: 2b QoE: low SoR: 0			
Re-directing gaze towards the neglected hemispace by temporary exposure to prisms inducing a rightward gaze shift (activates a cerebellar–cortical network and) can be used to treat neglect	WFNR	LoE: 2b, 4 QoE: low SoR: 0			
Patients are asked to lift horizontally extended wooden rods. If lifted too far to the right, the unbalanced rod gives direct feedback to the patient. Visuomotor feedback can be used to treat neglect	WFNR	LoE: 2b QoE: low SoR: 0			

Action observation of healthy limb in a mirror promotes recovery of contralesional motor deficits (of the affected limb behind the mirror) and visuospatial neglect and can be used to treat neglect	WFNR	LoE: 2b QoE: low SoR: 0			
Inhibitory rTMS of left parietal cortex reduces left-sided neglect (by reduction of interhemispheric imbalance) and can be used to treat neglect	WFNR	LoE: 2b QoE: low SoR: 0			
tDCS of parietal cortex (right-anodal or left-cathodal) has a potential of re-balancing interhemispheric imbalance [Evidence insufficient for recommendation]	WFNR	LoE: 4, 1b QoE: very low			
Galvanic vestibular stimulation, GVS, improves visual neglect, tactile extinction, and arm position sense (by activation of vestibular thalamocortical system and multimodal brain regions) and can be used to treat neglect	WFNR	LoE: 1b, 2b QoE: low SoR: 0			
Transcutaneous electrical nerve stimulation (TENS): Electric stimulation of contralesional neck (activates the right cerebral hemisphere) and can be used to treat neglect	WFNR	LoE: 1b, 4 QoE: low SoR: 0			
Left-sided motor action shifts attention to the neglected side, concurrent electrical arm stimulation facilitates this, and can be used to treat neglect	WFNR	LoE: 1b QoE: low SoR: 0			
Treatment of non-lateralized attention (sustained attention, alertness) has a potential to reduce neglect and motor deficits. [Evidence insufficient for recommendation]	WFNR	LoE: 4 QoE: very low			
Modulation of attention by different drugs have a potential to be helpful as an add-on treatment (not as a primary neglect therapy) [Evidence insufficient for recommendation]	WFNR	LoE: 1a QoE: very low			
Press-on (Fresnel) prism foils attached on the contralesional side of the two glasses of a conventional spectacle sparing the central (macular) visual field region have a potential to reduce shift gaze and attention to the neglected hemispace [Evidence insufficient for recommendation]	WFNR	LoE: 2b QoE: very low (mixed diagnostic group)			
APHASIA					
Recommendations: Aphasia Speech and language therapy is recommended for individuals with aphasia People with communication problems after stroke should be assessed by a speech and language therapist to diagnose the problem and to explain the nature and implications to the person, their family/carers and the multidisciplinary team. Reassessment in the first four months should only be undertaken if the results will affect decision-making or are required for mental capacity assessment People with communication problems after stroke should be assessed by a speech and language therapist to diagnose the problem and to explain the nature and implications to the person, their family/carers and the multidisciplinary team. Reassessment in the first four months should only be undertaken if the results will affect decision-making or are required for mental capacity assessment	AHA Au UK WFNR	I A Strong Nil	Multidisciplinary approach should include trained speech and language therapists	Limited number of trained speech and language therapists	Financing training program, workshops and online materials for healthcare provider
Published assessments of depression in aphasia can be considered	WFNR	LoE: 2a QoE: very low SoR: 0			

Published assessments of speech and language should be used to provide a profile of the speech or language disorder in patients with a positive screening result	WFNR	LoE: 2b QoE: very low SoR: B+ [clinical importance]			
Speech and language therapy should be provided to people with aphasia as individually indicated to reduce communication difficulties and enhance functional communication	WFNR	LoE: 1a QoE: very low to moderate SoR: B+			
Constraint-induced aphasia therapy can be considered for the treatment of people with aphasia, especially when promotion of verbal communication activity is the aim	WFNR	LoE: 1a QoE: very low to low SoR: 0			
Treatment for aphasia should include communication partner training Treatment to improve functional communication should include Supported Conversation techniques for potential communication partners of the person with aphasia Language training in specific groups or with computer programs has also been reported to be beneficial In the first four months after stroke, people with aphasia should be given the opportunity to practise their language and communication with a speech and language therapist or other communication partner as frequently as tolerated After the first four months, people with communication problems after stroke should be reviewed to determine their suitability for further treatment with the aim of increasing participation in communication and social activities. This may involve using an assistant or volunteer, family member or communication partner guided by the speech and language therapist, computer-based practice or other impairment-based or functional treatment People with communication problems after stroke should be considered for assistive technology and communication aids by an appropriately trained, experienced clinician People with aphasia after stroke whose first language is not English should be assessed and provided with information about aphasia and communication practice in their preferred language The carers and family of a person with communication problems after stroke, and health and social care staff, should receive information and training from a speech and language therapist which should enable communication partners to optimize engagement in rehabilitation, and promote autonomy and social participation People with persistent communication problems after stroke that limit their social activities should be offered information about local or national groups for people with aphasia, and referred as appropriate	AHA Ca ESAP UK WFNR	I B Evidence Level A). Nil LoE: 1a QoE: very low to low SoR: B+ [clinical relevance]	Comprehensive programs for speech and communication training involving caregivers for stroke patients	Major barriers to be surmounted include lack of awareness and low demand, absence of/or inadequate number of professionals	Financing coordinating programs, workshops and online materials for healthcare provider and caregivers

People with marked difficulty articulating words after stroke should be assessed for apraxia of speech and treated to maximize articulation of key words to improve speech intelligibility People with severe communication difficulties but good cognitive and language function after stroke should be assessed and provided with alternative or augmentative communication techniques or aids to supplement or compensate for limited speech					
Pharmacological therapy for aphasia. On the whole, drugs cannot yet be recommended to augment the effects of behavioral therapy for aphasia. Piracetam can be considered to improve aphasia, notably written language but further investigation of long-term effects and safety are needed	WFNR	LoE: 1a QoE: very low SoR: 0			
Aphasia therapy in the chronic phase therapy should be provided to people with aphasia who still wish to have therapy in the chronic phase post-stroke to improve their communication	WFNR	LoE: 1a QoE: very low to medium SoR: B+ [clinical relevance]			
People with aphasia who want to improve their language and communication abilities should be offered intensive therapy of a long duration in both the acute and chronic stages post-stroke, if they can tolerate it	WFNR	LoE: 1a QoE: medium SoR: B+ [clinical relevance]			
Self-managed computerized therapy for word finding practice: Use of self-managed computerized therapy for word finding practice should be considered as a method for delivering repetitive practice to improve word finding ability. However, combination with additional techniques to promote functional use of newly learned vocabulary in conversation need to be considered	WFNR	LoE: 1b QoE: medium SoR: B+			
Organizational setting for aphasia therapy. Individual, one-to-one or group therapy from a qualified speech and language therapist, SLT, computer-mediated therapy and volunteer-supported therapy can all be considered for the provision of speech and language therapy	WFNR	LoE: 1a QoE: very low SoR: 0			
Behavioral treatment approaches can be used to treat the impairment in apraxia of speech, AOS	WFNR	LoE: 2a QoE: very low SoR: 0			
tDCS or rTMS to enhance verbal production in aphasia can be considered	WFNR	LoE: 1a QoE: low SoR: 0			
Augmentative and alternative modes of communication can be considered	WFNR	LoE: 2a QoE: very low SoR: 0			
Communication partner training should be considered to facilitate communication	WFNR	LoE: 2a QoE: very low to low SoR: B+ [clinical relevance]			
Licensing of specific medical devices needs to be considered based on regional regulatory affairs and safety standards ought to be followed	WFNR	LoE: 1a QoE: high SoR: A+			
Intensive treatment is probably indicated, but there is no definitive agreement on the optimum amount, timing, intensity, distribution, or duration of treatment	AHA WFNR	IIa A	Speech and language therapists needed	Large number of Speech and language therapists needed	Training of speech and language therapists

Brain stimulation techniques as adjuncts to behavioral speech and language therapy are considered experimental and therefore are NOT currently recommended for routine use	AHA	III B	Training	Training	Training
Recommendations: Motor Speech Disorders: Dysarthria and Apraxia of Speech Class Level of Evidence, Interventions for motor speech disorders should be individually tailored and can include behavioral techniques and strategies that target:	AHA	I B	Multidisciplinary approach should include trained speech and language therapists	Limited number of trained speech and language therapists	Financing coordinated programs between clinical neurologists and Speech and Language Therapists for stroke cases with speech impairment
Physiological support for speech, including respiration, phonation, articulation, and resonance Global aspects of speech production such as loudness, rate, and prosody Augmentative and alternative communication devices and modalities should be used to supplement speech	AHA	I C	Comprehensive speech therapy program	Limited number of trained speech and language therapists	Financing coordinating programs, workshops and online materials for healthcare provider
SPASTICITY					
Recommendations: Spasticity Class Level of evidence Targeted injection of botulinum toxin into localized upper limb muscles is recommended to reduce spasticity, to improve passive or active range of motion, and to improve dressing, hygiene, and limb positioning	AHA	I A	Multidisciplinary approach should include trained neurologists for Botox injection	Limited number of trained neurologists	Financing training programs, workshops and online materials for clinical neurologists
For patients with spastic equinovarus deformity injections of botulinum toxin A should be considered to reduce the need of supportive devices in the chronic phase after stroke	WFNR	LoE: 1b QoE: moderate SoR: B+			
BoNT-A therapy should be considered for clinically relevant upper limb PSS that does not sufficiently respond to nonpharmacological treatment. In these cases, it should be entertained when the therapeutic goal is to support passive functions (prevention of contractures; hygiene, washing, dressing) and can be used in selected cases to support active function.	WFNR	Passive function LoE: 1a QoE: moderate SoR: B+ Active function LoE: 1a QoE: low SoR: 0			
BoNT-A therapy can be considered for clinically relevant lower limb post-stroke spasticity, PSS (ankle, knee, or hip) that does not sufficiently respond to nonpharmacological treatment (level of evidence 1b, quality of evidence moderate, 0 (functional benefit uncertain)) It is also an option to treat functionally relevant sustained clonus	WFNR	LoE: 3a QoE: low SoR: 0			
Instrumental injection guidance for BoNT-A Both ultrasound, US, electrical stimulation, ES, and EMG guidance can be used and are especially relevant when smaller or deeper muscles are injected	WFNR	LoE: 2a QoE: low SoR: 0			
Anatomical injection guidance for BoNT-A the injection of larger superficial muscles, non-instrumented manual needle placement can be adequate	WFNR	LoE: 2a QoE: low SoR: 0			
Targeted injection of botulinum toxin into lower limb muscles is recommended to reduce spasticity that interferes with gait function. Chemodenervation using botulinum toxin can be used to reduce spasticity, increase range of motion, and improve gait, for patients with focal and/or symptomatically distressing spasticity	AHA Ca	I A Evidence Level: Early-Level C; Late-Level A).	Multidisciplinary approach should include trained neurologists for Botox injection	Limited number of trained neurologists	Financing training programs, workshops and online materials for clinical neurologists

BoNT-A therapy can be considered to treat spasm-related and stretch- or exercise-induced spasticity-associated pain in spastic limb segments, both in the upper or lower extremity	WFNR	LoE: 1b QoE: low [partially indirect] SoR: 0			
Substantial difficulties to integrate a plegic and severely spastic arm in daily activities and spasticity-associated pain should trigger the evaluation of a botulinum neurotoxin A, BoNT-A treatment of the affected muscle groups	WFNR	LoE: 1a QoE: moderate SoR: B+			
NMES as adjuvant treatment for BoNT-A Neuromuscular electrostimulation. NMES applied for 3 to 5 days after BoNT-A therapy can be considered to enhance treatment effects in treated muscle groups	WFNR	LoE: 1a QoE: low (risk of bias) SoR: 0			
Adjuvant treatment for BoNT-A Safety aspects for the medical products used need to be taken into account. Other adjuvant therapies such as casting taping, mCIMT, and dynamic splint treatment can be used as individually indicated	WFNR	LoE: 1a QoE: very low (risk of bias, inconsistency) SoR: 0			
Phenol and alcohol neurolysis. Phenol and alcohol neurolysis can be considered for clinically relevant PSS that does not sufficiently respond to nonpharmacological treatment (and oral medication), especially when BoNT-A treatment is not feasible	WFNR	LoE: 2b QoE: low SoR: 0			
I Intrathecal baclofen, ITB for PSS Intrathecal baclofen. ITB can be considered for clinically relevant severe segmental or generalized PSS that does not sufficiently respond to other interventions	WFNR	LoE: 1b QoE: moderate SoR: 0 [beneft risk for harm assessment]			
Organization of ITB treatment. ITB treatment ought to be tested, initiated, adjusted, and monitored with long-term support (including emergency work-up when indicated) by physicians experienced with the treatment	WFNR	LoE: 1b QoE: moderate SoR: A+ [beneft risk for harm assessment]			
People with motor weakness after stroke should be assessed for spasticity as a cause of pain, as a factor limiting activities or care, and as a risk factor for the development of contractures B People with stroke should be supported to set and monitor specific goals for interventions for spasticity using appropriate clinical measures for ease of care, pain and/or range of movement C People with spasticity after stroke should be monitored to determine the extent of the problem and the effect of simple measures to reduce spasticity e.g., positioning, passive movement, active movement (with monitoring of the range of movement and alteration in function) and/or pain control D People with persistent or progressive focal spasticity after stroke affecting one or two areas for whom a therapeutic goal can be identified (e.g., ease of care, pain) should be offered intramuscular botulinum toxin. This should be within a specialist multidisciplinary team and be accompanied by rehabilitation therapy and/or splinting or casting for up to 12 weeks after the injections. Goal attainment should be assessed 3-4 months after the injections and further treatment planned according to response E People with generalized or diffuse spasticity after stroke should be offered treatment with skeletal muscle relaxants (e.g., baclofen, tizanidine) and monitored for adverse effects, in	UK	Nil	Multidisciplinary approach should include spasticity service with trained professionals	Limited number of trained professionals for spasticity service	Financing coordinated programs with spasticty service professionals for post-stroke care

particular sedation and increased weakness. Combinations of antispasticity drugs should only be initiated by healthcare professionals with specific expertise in managing spasticity F People with stroke should only receive intrathecal baclofen, intraneural phenol or similar interventions in the context of a specialist multidisciplinary spasticity service G People with stroke with increased tone that is reducing passive or active movement around a joint should have the range of passive joint movement assessed. They should only be offered splinting or casting following individualized assessment and with monitoring by appropriately skilled staff H People with stroke should not be routinely offered splinting for the arm and hand					
It is important to keep in mind that spasticity could be one component of motor impairments and clinical problems following stroke and may contribute to reduction in activities of daily living and quality of life in about 10–12% of chronic stroke survivors. Spasticity should be classified according to the topical distribution as focal, multifocal, segmental, hemispastic, paraspastic, or as generalized spasticity. It should primarily be assessed and documented by standardized validated clinical assessment scales such as the Ashworth Scale, AS, modified Ashworth Scale MAS, or the Tardieu scale, TS.	AS, mAS LoE: 2a QoE: moderate SoR: B+ TS: LoE: 2b QoE: low SoR: 0				
An important component of assessment and management decision-making is arriving at treatment goals. Identifying goals that are mutually agreed upon by the patient, caregiver, and clinician a priori should be an important step in spasticity treatment decision-making.	LoE: 2b QoE: moderate SoR: B+				
Oral antispasticity agents can be useful for generalized spastic dystonia but may result in dose-limiting sedation or other side effects.	AHA	IIa A	Multidisciplinary approach should include spasticity service with trained professionals	Limited number of trained professionals for spasticity service	Financing coordinated programs with spasticity service professionals for post-stroke care
Oral systemic medications can be used for segmental and generalized spasticity but may be associated with dose-dependent adverse effects.	LoE: 2b QoE: low SoR: 0				
Selection of type of oral medication depends on individual circumstances and may include combinations. These medications should be titrated slowly, and both clinical benefits and unwanted effects need to be monitored.	LoE: 1a QoE: low SoR: B+ [clinical reasoning]				
The use of splints and taping are NOT recommended for prevention of wrist and finger spasticity after stroke	AHA	III B	Training	Training	Training
Splints and other orthoses used to immobilize joints (recovery): Using splints and other orthoses to intermittently immobilize joints, e.g., the wrist of the severely affected arm or shoulder strapping (glenohumeral, scapulo-thoracal), does not facilitate motor recovery and should not be used for this therapeutic goal	WFNR	LoE: 1a QoE: moderate SoR: B-			

In the chronic stage, an orthosis with or without electrical stimulation should be applied in appropriate patients if available to support gait velocity as an assistive device (indirect effect)	WFNR	LoE: 1b QoE: moderate SoR: B+			
Intensive task specific strength-endurance training, gait training with acoustic rhythmic stimulation or task specific with additional cognitive elements (e.g., motor imagery, motor observation, knowledge of result, acoustic feedback, dual tasks) can also be used in the subacute and chronic stage to improve gait velocity	WFNR	LoE: 2b QoE: low SoR: 0			
	WFNR				
In order to increase walking distance in patients who can walk independently with or without an aid or with little help task- and goal-specific endurance training ought to be performed, especially in the subacute phase after stroke	WFNR	LoE: 2b-1a QoE: high SoR: A+			
If this is not possible, an intensive gait training with or without a use of a treadmill (especially progressive aerobic treadmill training), or an intensive supervized home training program (strength, endurance, and balance training) with progression should be performed in the subacute stage	WFNR	LoE: 2b, 1b QoE: moderate SoR: B+			
In the chronic stage, task-specific endurance training, e.g., progressive aerobic treadmill training should be performed	WFNR	LoE: 1b QoE: moderate SoR: B+			
Splints and other orthoses used to immobilize joints (pain): It can be used to prevent or treat pain associated with severe paresis at these joints	WFNR	LoE: 1a QoE: low SoR: 0			
Intensive task specific strength-endurance training, gait training with acoustic rhythmic stimulation or task specific with additional cognitive elements (e.g., motor imagery, motor observation, knowledge of result, acoustic feedback, dual tasks) can also be used in the subacute and chronic stage to improve gait velocity	WFNR	LoE: 2b QoE: low SoR: 0			
Surgical procedures for PSS In individual cases, after careful examination in the multi-professional team and exhaustion of other reversible treatment options for spastic movement disorder, surgical procedures may be considered as treatment option in chronic spastic movement disorder following stroke	WFNR	LoE: 4 QoE: very low SoR: 0			
BALANCE					
Individuals with stroke should be evaluated for balance, balance confidence, and fall risk	AHA	I C	Neurologists, physiotherapists are required for balance and fall evaluation	Need large number of neurologists and physiotherapists	Recommend training of more neurologists and physiotherapists globally
Individuals with stroke who have poor balance, low balance confidence, and fear of falls or are at risk for falls should be provided with a balance training program For patients with balance disorders post stroke, balance training should be offered It has been demonstrated that exercising postural control with visual feedback while standing on a force platform improves the postural sway in stance of patients with a stroke Studied for early and chronic rehabilitation It has been demonstrated that exercising balance during various activities results in improved sitting and standing balance and improved performance of basic activities of daily living by stroke patients Studied for early, late and chronic rehabilitation	AHA Ca Ne	I A Evidence Level A (Level 1)	Physiotherapists are required for balance training	Need large number of physiotherapists	Recommend training of more physiotherapists for stroke patients globally

Repetitive task training is a therapeutic option when improvement of arm activities is the therapeutic goal	WFNR	LoE: 1a QoE: moderate SoR: 0			
A three-week course of daily arm ability training should be considered when improvement of sensorimotor skilfulness (e.g., dexterity) is the therapeutic goal for patients with mild-to-moderate arm paresis	WFNR	LoE: 1b QoE: moderate SoR: B+			
MOBILITY					
Recommendations: Mobility Intensive, repetitive, mobility- task training is recommended for all individuals with gait limitations after stroke Task and goal-oriented training that is repetitive and progressively adapted should be used to improve performance of selected lower-extremity tasks such as walking distance and speed and sit to stand It has been demonstrated that training specific skills, such as exercising balance while standing and reaching to grasp objects, has a favourable effect on the specific skill being trained by stroke patients, in all phases of rehabilitation People with loss of movement and/or ataxia after stroke sufficient to limit their activities should be assessed by a physiotherapist with experience in neurological rehabilitation People with loss of movement and/or ataxia after stroke should be taught task-specific, repetitive, intensive exercises or activities that will increase strength People with impaired sitting balance after stroke should receive trunk training exercises People with significant impairment of their balance and walking ability after stroke should receive progressive balance training, functional task-specific training, lower limb strengthening exercises and be considered for an ankle-foot orthosis People with moderate to severe limitation of their walking ability after stroke should be assessed for a walking aid to improve their stability People with stroke who are able to walk with or without assistance should undergo task specific walking training with a cardiorespiratory and/or muscle strength focus at sufficient intensity to improve endurance and walking speed People with limited ability to walk after stroke should be assessed by a physiotherapist with experience in neurological rehabilitation to guide management People with limited mobility after stroke should be assessed, provided with and trained in how to use appropriate mobility aids including a wheelchair to enable safe independent mobility	AHA Ca ESAP Ne UK	I A Evidence Level A Level 1 Nil	Physiotherapists are required for mobility and gait training	Need large number of physiotherapists	Recommend training of more physiotherapists for stroke patients globally
In the chronic stage an orthosis with electrical peroneal stimulation should be applied as an assistive device to improve walking distance (indirect effect) if indicated and available	WFNR	LoE: 1b QoE: moderate SoR: B+			
Elements of cognitive training (motor imagery, motor observation), additional stimulation techniques (peroneal stimulation, functional electrical stimulation) can also enhance walking distance and can be used in the subacute and chronic phase	WFNR	LoE: 2b, 1b QoE: low SoR: 0			

Dedicated training: A dedicated active arm motor control training of at least 2 h per week over several weeks ought to be provided when acceleration of arm motor recovery is intended post-stroke	WFNR	LoE: 1a QoE: high SoR: A+			
Training time per day (subacute): Increasing the therapy time up to 3 h per day can create a benefit in the subacute stage and can be considered individually	WFNR	LoE: 1b QoE: moderate SoR:0			
Training time per week (chronic): At least 3 h per week of dedicated active arm motor rehabilitation (including circuit class approaches and the use of training apparatuses or home practice with intermittent supervision) with regular evaluation of therapeutic progress are recommended for prolonged therapy in the chronic stage when improvements at impairment or activity level are intended and can be observed	WFNR	LoE: 1b QoE: moderate SoR: B+			
Organization of training: Depending on individual circumstances (patient and service) the following should be entertained as therapeutic options: (I) one-to-one therapy, (II) circuit class training that can integrate the use of passive training apparatuses, and (III) intermittently supervized home training, the latter ideally with dedicated training manuals for patients with mild, moderate, or severe paresis, respectively, with a focus on repetitive impairment- and activity-oriented training, and documentation of the training	WFNR	LoE: 1b QoE: moderate SoR: B+			
Strategy when prognosis is very poor: In cases with an individually very poor prediction (complete paralysis with diagnosed severe corticospinal tract damage (loss of motor evoked potentials (MEP) with transcranial magnetic stimulation (TMS), posterior limb of internal capsule damage on MRI diffusion tensor imaging (DTI)), a therapeutic focus on prevention of secondary complications (only) for the plegic arm and teaching compensatory strategies with the non-paretic arm can be considered already early after stroke	WFNR	LoE: 2b QoE: low [imprecision] SoR: 0			
rTMS for arm rehabilitation Contralesional low frequency, LF rTMS or ipsilesional high frequency, HF rTMS or intermittent theta burst stimulation, iTBS of the primary hand motor cortex (e.g., five sessions) can be considered as adjunct therapy by experienced personnel when available and when used within safety guidelines, preferably early after stroke	WFNR	LoE: 1a QoE: moderate SoR: 0 [resource implications]			
Individuals with stroke should be prescribed and fit with an assistive device or orthosis if appropriate to improve balance	AHA Ca	I A (Evidence Level: Early-Level A; Late-Level A).	Physiotherapists; orthotic devices	Need large number of physiotherapists; Need orthotic devices	Training of physiotherapists, production of orthotic devices
Conventional gait training combined with training using mechanical devices (treadmill, end-effector device, or exoskeleton), strength and endurance training, training to stand on an unstable or progressively smaller support base, acoustic feedback during walking, and orthopaedic shoe when indicated may also improve balance in the subacute and chronic stages after stroke and can be used	WFNR	LoE: 1b, 2b QoE: low SoR: 0			
Dynamic balance training as an integral part of an intensive gait training In order to improve balance in the subacute stage after stroke and reduce the number of falls in patients who can walk independently with or without an aid or with little help dynamic balance training should be performed as an integral part of an intensive gait training	WFNR	LoE: 1b QoE: moderate SoR: B+			
An intensive supervizd home training program with progression and a motor relearning program have the same quality of evidence support for their use in the subacute stage after stroke and should be considered to improve balance in the subacute stage	WFNR	LoE: 1b QoE: moderate SoR: B+			

An ankle foot orthosis after stroke is recommended in individuals with remediable gait impairments (e.g., foot drop) to compensate for foot drop and to improve mobility and paretic ankle and knee kinematics, kinetics, and energy cost of walking Ankle-foot orthoses should be used on selected patients with foot drop following proper assessment and with follow-up to verify its effectiveness People with stroke who have compromized ankle/foot stability and/or reduced ability to dorsiflex the foot ('foot-drop') that impedes safe and efficient walking should be offered an ankle-foot orthosis to improve walking and balance. The orthosis should be evaluated and individually fitted before long-term use	AHA Ca UK	I A Evidence Level A Nil	Physiotherapists; orthotic devices	Need large number of physiotherapists; Need orthotic devices	Training of physiotherapists, production of orthotic devices
Group therapy with circuit training is a reasonable approach to improve walking. Stroke survivors with difficulty walking should be given the opportunity to undertake tailored repetitive practice of walking (or components of walking) as much as possible Circuit class training for walking and other mobility-related functions and activities: It has been demonstrated that circuit class training (CCT) for walking and other mobility-related functions and activities improves walking distance/speed, sitting and standing balance and walking ability, and reduces inactivity in patients with a stroke Walking distance/speed studied for ER, LR and RC, sitting and standing balance for ER, LR and RC, walking ability for ER, LR, and RC, and inactivity for LR and RC	AHA Au Ne	IIa A Strong recommendation (Level 1)	Physiotherapists needed to provide circuit training.	Need large number of physiotherapists	Training of physiotherapists
For stroke survivors who have difficulty sitting, practicing reaching beyond arm's length while sitting with supervision/assistance should be undertaken For stroke survivors who have difficulty in standing up from a chair, practice of standing up should be undertaken For stroke survivors who have difficulty standing, task-specific practice of standing balance should be provided. Strategies could include: practicing functional tasks while standing walking training that includes challenge to standing balance (e.g., overground walking, obstacle courses)	Au	Strong	Physiotherapists needed	Need large number of physiotherapists	Training of physiotherapists, globally
It has been demonstrated that body weight supported treadmill training improves the comfortable walking speed and walking distance of patients with a stroke. Studied for early and chronic rehabilitation It has been demonstrated that treadmill training without body-weight support is more effective in increasing maximum walking speed and width of gait than conventional gait training for patients with a stroke Treadmill-based gait training (with or without body weight support) can be used to enhance walking speed, and distance walked when overground training is not available or appropriate People who are able to walk independently after stroke should be offered treadmill training with or without body weight support or other walking-orientated interventions at a higher intensity than usual care and as an adjunct to other treatments	Ne Ca UK	Level 1 Evidence Level: Early-Level A; Late-Level A). Nil	Need of a stroke rehabilitation gymnasium with treadmill or without body support	Cost of establishing the gymnasium and treadmill; hospitals should try to invest in neurorehabilitation gymnasium	WSO Task Force on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services to all eligible stroke patients in their countries and regions

People who cannot walk independently after stroke should be considered for electromechanical-assisted gait training including body weight support					
FES should be used to improve strength and function (gait) in selected patients, but the effects may not be sustained People with stroke who have reduced ability to dorsiflex the foot ('foot-drop') should be offered functional electrical stimulation to improve their gait People with stroke should only receive therapeutic electrical stimulation for treatment of the leg (other than for foot-drop) in the context of a clinical trial	Ca UK	(Evidence Level: Early-Level A; Late-Level A). Nil	FES is a cheap stroke rehabilitation for stroke patients with foot dorsiflexion weakness	Functional electrical stimulators are not very expensive	Availability should be ensured in neurorehabilitation services
Robot-assisted gait training It has been demonstrated that robot-assisted gait training for stroke patients who are unable to walk independently improves their comfortable walking speed, maximum walking speed, walking distance, heart rate, sitting and standing balance, walking ability and performance of basic activities of daily living, compared to conventional therapy (including overground walking) Electromechanical (robotic) assisted gait training devices could be considered for patients who would not otherwise practice walking. They should not be used in place of conventional gait therapy	Ne Ca	Level 1 Evidence Level: Early-	Robotic rehabilitation lab, trained therapists in robotic rehabilitation	Very expensive; tertiary centers should have this facility	Ensure availability; low-cost robotic rehabilitation could be developed in LMICs
It has been demonstrated that combining robot-assisted gait training with functional electrostimulation of the paretic leg improves the sitting and standing balance and walking ability of patients with a stroke, compared to conventional therapy (including overground walking). (Level 1)	Ne	Level 1	Same	Same	Same
Use of other means to support restoration of the ability to walk. Intensive gait training to restore the ability to walk can also use a treadmill if available and appropriate, motor imagery as one component, or cyclic multichannel stimulation to generate movements similar to a walking pattern	WFNR	LoE: 2b,1b QoE: low SoR: 0			
Intensive gait training to improve gait in stroke survivors who walk independently or with little help: In patients who can walk independently with or without an aid or with little help an intensive and progressive gait training should be performed in the subacute stage after stroke, and can be performed (intermittently) in the chronic phase after stroke	WFNR	Subacute: LoE: 1b QoE: moderate SoR: B+ Chronic: LoE: 1b QoE: low (indirect) SoR: 0			
Use of other means to improve gait: Intensive gait training to improve gait can also include task-specific training combined with motor imagery, functional electrical stimulation, additional electroacupuncture, and/or usage of walking devices (e.g., crane, stick) (subacute phase)	WFNR	LoE: 2b,1b QoE: low SoR: 0			

Rhythmic auditory stimulation (RAS) could be considered for improving gait parameters in stroke patients, including gait velocity, cadence, stride length and gait symmetry Virtual reality training (such as non-immersive technologies) could be considered as an adjunct to conventional gait training Mental practice could be considered as an adjunct to lower extremity motor retraining	Ca	(Evidence Level A).	Gait lab, trained therapists Virtual rehabilitation technology and trained therapists Training for therapists	Expensive Same Technology and training required	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services to all eligible stroke patients in their countries and regions.
Overground gait training It has been demonstrated that overground gait training by stroke patients who are able to walk without physical support is more effective in increasing walking distance and reducing anxiety than walking on a treadmill. (Level 1)	Ne	Level 1	Therapists	No technology is needed	Services should be made available
Incorporating cardiovascular exercise and strengthening interventions is reasonable to consider for recovery of gait capacity and gait-related mobility tasks People with stroke, including those who use wheelchairs or have poor mobility, should be advised to participate in exercise with the aim of improving aerobic fitness and/or muscle strength unless there are contraindications	AHA UK	IIa A Nil	Therapists, rehabilitation gymnasium	Fitness of patients, comorbid medical conditions, training in technique is essential	Same
Individually tailored aerobic training involving large muscle groups should be incorporated into a comprehensive stroke rehabilitation program to enhance cardiovascular endurance Heart rate and blood pressure should be monitored during training to ensure safety and attainment of target exercise intensity iii. To ensure long-term maintenance of health benefits, a planned transition from structured aerobic exercise to more self-directed physical activity at home or in the community should be implemented	Ca	(Evidence Level: Early-Level A; Late-Level A)	Same	Same	Same
NMES is reasonable to consider as an alternative to an AFO for foot drop	AHA	IIa A	Therapists, availability of AFO	Simple and low cost	Ensure availability
It has been demonstrated that exercising, walking and other mobility-related functions and activities under the supervision of an informal caregiver improves the performance of basic activities of daily living for the patient with a stroke, and reduces the perceived burden of care for the informal caregiver	Ne	(Level 1)	Therapists and training of caregivers	Caregiver availability; motivation of caregivers	Ensure inclusion in stroke rehabilitation protocols particularly in LMICs
Training muscle strength in the paretic leg It has been demonstrated that training the muscle strength of the paretic leg or both legs of stroke patients increases their muscle strength and resistance to passive movement, and improves the patient's gait in terms of cadence, symmetry, and stride length	Ne	(Level 1)	Therapists and training	Lack of therapists; involvement of caregivers	Ensure the incorporation in neurorehabilitation protocols

Training aerobic endurance It has been demonstrated that training aerobic endurance increases the maximum oxygen consumption, respiratory functions in terms of FEV1 and expiratory flow per minute and workload of patients with a stroke. (Level 1) *Aerobic endurance training combined with strength training* It has been demonstrated that a combination of aerobic endurance training and strength training improves selective movements, muscle strength of the paretic leg, comfortable and maximum walking speed, walking distance, maximum oxygen consumption, heart rate in exertion, balance, level of physical activity in everyday life, and quality of life for patients with a stroke. (Level 1)	Ne	Level 1	Therapists, rehabilitation gymnasium Same	Fitness of patients, comorbid medical conditions; training in technique is essential Same	Ensure availability Same
Hydrotherapy It has been demonstrated that hydrotherapy increases the muscle strength of the paretic leg of patients with a stroke	Ne	Level 1)	Infrastructure and trained therapists	Expensive	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services to all eligible stroke patients in their countries and regions
Electrostimulation of the paretic leg using surface electrodes It has been demonstrated that neuromuscular stimulation (NMS) of the paretic leg improves selective movements, muscle strength, and resistance to passive movements for patients with a stroke.	Ne	*Level 1)*	Therapists and technology	Easy to use	Ensure availability, low cost
It has been demonstrated that transcutaneous electrical nerve stimulation (TENS) of the paretic leg improves muscle strength and walking ability and related activities for patients with a stroke.	Ne	*(Level 1)*	Same	Same	Same
UPPER EXTREMITY ACTIVITY, INCLUDING ADLs, IADLs, TOUCH, AND PROPRIOCEPTION					
Functional tasks should be practiced: that is, task-specific training, in which the tasks are graded to challenge individual capabilities, practiced repeatedly, and progressed in difficulty on a frequent basis Patients should engage in training that is meaningful, engaging, repetitive, progressively adapted, task specific and goal-oriented in an effort to enhance motor control and restore sensorimotor function ii. Training should encourage the use of patients' affected limb during functional tasks and be designed to simulate partial or whole skills required in activities of daily living (e.g., folding, buttoning, pouring, and lifting) The team should promote the practice and transfer of skills gained in therapy into the patient's daily routine Therapy should include repetitive and intense use of novel tasks that challenge the patient to acquire the necessary skills needed to perform functional tasks and activities (Evidence Level A). People with stroke with potential or actual arm movement should be given every opportunity to practice functional activities. Practice should be characterized by movements that are of high intensity, repetitive and are task-specific. These activities may be bilateral or unilateral depending on the task.	AHA Ca UK	I A (Evidence Level A), Nil	Therapists, training Same for all	Availability of therapists	Ensure incorporation in stroke rehabilitation protocols

All individuals with stroke should receive ADL training tailored to individual needs and eventual discharge setting	AHA	I A			
Therapeutic positioning of the paretic arm It has been demonstrated that therapeutic positioning of the paretic arm results in preservation of the passive exorotation of the shoulder of patients with a stroke	Ne	Level 1	Therapists and protocols	Availability of therapists	Ensure incorporation in stroke rehabilitation protocols
People with functional loss in their arm after stroke should have the risk of shoulder pain reduced by: – careful positioning of the arm, with the weight of the limb supported – ensuring that family/carers handle the affected arm correctly, avoiding mechanical stress and excessive range of movement – avoiding the use of overhead arm slings and pulleys B People with arm weakness after stroke should be asked regularly about shoulder pain C People who develop shoulder pain after stroke should: – have the severity monitored and recorded regularly, using a validated pain assessment tool. – have preventative measures put in place – be offered regular simple analgesia D People with shoulder pain after stroke should only be offered intra-articular steroid injections if they also have inflammatory arthritis	UK	Nil	Therapists and caregivers Therapists Rehabilitation physicians	Availability of therapists and caregivers Same Training, other comorbid musculoskeletal conditions	Same Same Same
CIMT or its modified version is reasonable to consider for eligible stroke survivors Traditional or modified constraint-induced movement therapy (CIMT) should be considered for a select group of patients who demonstrate at least 20 degrees of active wrist extension and 10 degrees of active finger extension, with minimal sensory or cognitive deficits For stroke survivors with some active wrist and finger extension, intensive constraint-induced movement therapy (minimum 2 hours of active therapy per day for 2 weeks, plus restraint for at least 6 hours a day) should be provided to improve arm and hand use. Trunk restraint may also be incorporated into the active therapy sessions at any stage post-stroke. Original Constraint-Induced Movement Therapy (CIMT) It has been demonstrated that original CIMT improves the dexterity, perceived use of arm and hand, quality of arm and hand movements, and quality of life of patients with a stroke. (Level 1) High-intensity modified Constraint-Induced Movement Therapy (mCIMT) It has been demonstrated that high-intensity CIMT improves the dexterity, perceived use of arm and hand, and quality of arm and hand movements of patients with a stroke. Low-intensity modified Constraint-Induced Movement Therapy (mCIMT) It has been demonstrated that low-intensity mCIMT improves the selective movements, dexterity, perceived use of arm and hand, quality of arm and hand movements, and performance of basic activities of daily living of patients with a stroke	AHA Ca Au Ne UK	IIa A Evidence Level A Strong recommendation Level 1 Nil	Therapists and training Same for all	Not widely practiced; training is needed	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services to all eligible stroke patients in their countries and regions

People with stroke who have 20 degrees of active wrist extension and 10 degrees of active finger extension in the affected hand should be considered for constraint-induced movement therapy. People with stroke who have been assessed as cognitively suitable to participate in mental practice of an activity should be trained and encouraged to use it to improve arm function, as an adjunct to conventional therapy					
Wearing a restraint of the non-affected arm outside therapeutic sessions is recommended when a "transfer package" is offered during therapy	WFNR	LoE: 1b QoE: moderate SoR: B+			
For patients with moderate arm paresis showing compensatory trunk displacement during reaching, using a trunk restraint while training reaching movements can be considered	WFNR	LoE: 1a QoE: low SoR: 0			
Patients showing learnt non-use while having only mild-to-moderate paresis with some preserved hand function and no major problems with pain or spasticity in their affected arm should be offered modified constraint-induced movement therapy, mCIMT or CIMT (the latter when beyond the acute phase) when the actual amount of use of the affected arm is the therapeutic target, i.e., to reverse learnt non-use	WFNR	LoE: 1a QoE: high SoR: B+			
People without movement in the affected arm after a stroke should be trained in how to care for their affected arm and monitored for any change	UK	Nil	Same	Same	Same
Hand and wrist orthoses (splints) should not be used as part of routine practice as they have no effect on function, pain or range of movement	Au	Strong recommendation against	Training	Same	Ensure incorporation in protocols
Robotic therapy is reasonable to consider, delivering more intensive practice for individuals with moderate to severe upper limb paresis People with reduced arm function after a stroke should only be offered robot-assisted movement therapy or neuromuscular electrical stimulation as an adjunct to conventional therapy in the context of a clinical trial	AHA UK Ne	IIa A Nil Level 1	Robotic lab, trained therapists	Expensive; tertiary centres could develop	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services to all eligible stroke patients in their countries and regions
Arm robot therapy is also an option in the chronic phase	WFNR	LoE: 1a QoE: low [uncertain effects] SoR: 0			
If available, arm robot therapy should be offered on a daily basis especially to increase dosage/intensity of repetitive selective movements in the acute/subacute phase when selective movement capacity recovery is therapeutic goal	WFNR	LoE: 1a QoE: high SoR: B+ [unclear long-term effects]			
Mirror therapy should be considered as an adjunct to motor therapy for select patients. It may help to improve upper extremity motor function and ADLs	Ca WFNR	Evidence Level: Early-Level A; Late-Level A).	Training	Low cost	Ensure availability
Daily mirror therapy as additional training for several weeks, e.g., as supervized self-training, should be considered when motor improvement at impairment and/or activity level is intended	WFNR	LoE: 1a QoE: moderate SoR: B+			

It has been demonstrated that virtual reality training of the paretic arm and hand as an add-on to regular exercise therapy for patients with a stroke improves the performance of basic activities of daily living. Studied for ER and RC. Virtual reality, including both immersive technologies such as head mounted or robotic interfaces and non-immersive technologies such as gaming devices can be used as adjunct tools to other rehabilitation therapies as a means to provide additional opportunities for engagement, feedback, repetition, intensity and task-oriented training	Ne Ca	(Level 1) (Evidence Level: Early-Level A; Late-Level A).	Technology and training	Expensive; tertiary centers	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services to all eligible stroke patients in their countries and regions
NMES is reasonable to consider for individuals with minimal volitional movement within the first few months after stroke or for individuals with shoulder subluxation Functional Electrical Stimulation (FES) targeted at the wrist and forearm muscles should be considered to reduce motor impairment and improve function Electrostimulation of the paretic arm using surface electrodes NMS of the paretic wrist and finger extensors It has been demonstrated that neuromuscular electrostimulation (NMS) of the paretic wrist and finger extensors of patients with a stroke is not more effective in terms of selective movements, muscle strength, active range of motion for wrist and finger extension, and dexterity than other interventions. (Level 1) NMS of the paretic wrist and finger flexors and extensors It has been demonstrated that neuromuscular stimulation (NMS) of the paretic wrist and finger flexors and extensors of patients with a stroke improves selective movements and muscle strength. (Level 1) NMS of the paretic shoulder muscles It has been demonstrated that neuromuscular electrostimulation (NMS) of the paretic shoulder muscles of patients with a stroke reduces glenohumeral subluxation. EMG-NMS of the paretic wrist and finger extensors: It has been demonstrated that EMG-triggered neuromuscular electrostimulation (EMG-NMS) of the paretic wrist and finger extensors of patients with a stroke improves selective movements, active range of motion, and dexterity. (Level 1)	AHA Ca Ne	IIa A Evidence Level A Level 1	Therapists, technology and availability Same for all	Training	Ensure availability
Cyclic, cNMES of wrist and finger flexors and extensors, or when EMG-triggering is voluntarily possible, EMG-NMES of wrist and finger extensors, in selected cases as functional electrical stimulation, FES can be used to enhance selective motion capacity and arm activities	WFNR	LoE: 1a QoE: low SoR: 0			
cNMES of shoulder muscles can be applied to treat subluxation	WFNR	LoE: 1a QoE: low SoR: 0			
Mental practice is reasonable to consider as an adjunct to upper extremity rehabilitation services	AHA	IIa A	Therapists and training	Training	Ensure availability
Mental practice is an alternative option after actual motor training sessions with the paretic arm	WFNR	LoE: 1a QoE: moderate SoR: 0			

Strengthening exercises are reasonable to consider as an adjunct to functional task practice For stroke survivors with reduced strength in their arms or legs, strength training should be provided Strength training should be considered for persons with mild to moderate upper extremity function in both subacute and chronic phases of recovery Strength training does not aggravate tone or pain	AHA Au Ca	IIa B Weak (Evidence Level A).	Therapists and training Same for all	Training	Ensure implemented in protocols
Strengthening exercises can be an element of individualized therapy	WFNR	LoE: 1a QoE: moderate SoR: 0			
Virtual reality is reasonable to consider as a method for delivering upper extremity movement practice	AHA	IIa B	Technology	Expensive	Ensure availability
Purpose-built virtual reality therapy systems (and gaming consoles) can be used to improve selective motion capacity	WFNR	LoE: 1a QoE: low SoR: 0			
Virtual reality therapy systems (arm weight support): Purpose-built virtual reality therapy systems with arm weight support can be used to improve selective motion capacity and arm activities with severe incomplete arm paresis	WFNR	LoE: 1b QoE: low SoR: 0			
Strengthening exercises can be an element of individualized therapy	WFNR	LoE: 1a QoE: moderate SoR: 0			
Bilateral training paradigms may be useful for upper limb therapy	AHA	IIb A	Therapists and training	Training	Ensure including in protocols
It has been demonstrated that interventions to improve the somatosensory functions of the paretic arm and hand of patients with a stroke improve the somatosensory functions and reduce the resistance to passive movements	Ne	Level 1	Same	Same	Same
Somatosensory (especially thermal) stimulation is an option as adjunct therapy	WFNR	LoE: 1b QoE: moderate SoR: 0			
Acupuncture is not recommended for the improvement of ADLs and upper extremity activity	AHA	III A	Create awareness	Very commonly used in Asia; needs well planned RCTs	Do not include in protocols till strong evidence emerges
Acupuncture for arm rehabilitation: In the subacute phase also acupuncture	WFNR	LoE: 1b QoE: low SoR: 0			
Recommendations: Adaptive equipment, durable medical devices, orthotics, and wheelchairs Ambulatory assistive devices (e.g., cane, walker) should be used to help with gait and balance impairments, as well as mobility efficiency and safety, when needed	AHA	I B	Therapists, companies and training	Simple low cost	Ensure availability
AFOs should be used for ankle instability or dorsiflexor weakness	AHA	I B	Same for all		
Wheelchairs should be used for non-ambulatory individuals or those with limited walking ability	AHA	I C	Same	Same	Same

Adaptive and assistive devices should be used for safety and function if other methods of performing the task/activity are not available or cannot be learned or if the patient's safety is a concern	AHA	I C	Same	Same	Same
Later rehhabilitation Targeted training, such as balance training, gait training with different devices, and upper extremity training more than one year after stroke seems to have a positive effect	ESAP	IIa A	Therapists and training	Training	Ensure including in protocol
Intensive gait training to re-establish the ability to walk in stroke survivors who cannot walk without help: In the subacute stage after stroke, intensive gait training should be performed in order to re-establish the ability to walk in stroke survivors who cannot walk without help	WFNR	LoE: 1b QoE: low to moderate SoR: B+			
Use of electromechanical gait-training re-establish the ability to walk in stroke survivors who cannot walk without help: If available and appropriate, intensive physiotherapy should be combined with the use of an end-effector–based device or an exoskeleton (for electromechanical gait training)	WFNR	LoE: 1a QoE: high SoR: B+			
CHRONIC CARE MANAGEMENT – HOME AND COMMUNITY-BASED PARTICIPATION					
After successful screening, an individually tailored exercise program is indicated to enhance cardiorespiratory fitness and to reduce the risk of stroke recurrence	AHA ESAP Au	I A (for improved fitness); B (for reduction of stroke risk) Strong	Therapists and training	Training	Same
Strategies to address specific barriers to physical activity related to patients, health care providers, family, and/or the environment should be employed	Ca	(Evidence Level: Early-Level A; Late-Level A).	Same	Same	Same
After completion of formal stroke rehabilitation, participation in a program of exercise or physical activity at home or in the community is recommended. (Access to green areas and walking space may facilitate physical activity)	AHA ESAP Au	I A Strong	Same	Same	Same
Community-dwelling stroke survivors who have difficulties performing daily activities should be assessed by a trained clinician			Same	Same	Same
Community-dwelling stroke survivors with confirmed difficulties in personal or extended ADL should have specific therapy from a trained clinician (e.g., task-specific practice and training in the use of appropriate aids) to address these issues			Same	Same	Same
TREATMENTS/INTERVENTIONS FOR VISUAL IMPAIRMENTS					
For deficits in eye movements: Eye exercises for treatment of convergence insufficiency are recommended	AHA	I A	Therapists and training	Training	Ensure incorporating in protocols
As the available observational studies consistently showed a significant treatment effect of binocular fusion treatment in about 90% of treated patients (with convergence/fusion deficits), these treatments can be used	WFNR	LoE: 2b QoE: low SoR: 0			
Eye exercises for treatment of convergence insufficiency are recommended	AHA	I A	Same	Same	Same
Multimodal audio-visual spatial exploration training appears to be more effective than visual spatial exploration training alone and is recommended to improve visual scanning	AHA	I B	Same	Same	Same

The use of behavioral optometry approaches involving eye exercises and the use of lenses and coloured filters to improve eye movement control, eye focusing, and eye coordination is not recommended	AHA	III B	Same	Same	Same
RECOMMENDATIONS; SOCIAL AND FAMILY CAREIVER SUPPORT					
It may be useful for the family/caregiver to be an integral component of stroke rehabilitation	AHA ESAP	IIb A	Therapists and caregivers	Training and availability of caregivers	Ensure implementation
It may be reasonable that family/caregiver support include some or all of the following on a regular basis: Education Training Counseling Development of a support structure Financial assistance Stroke survivors and their carers should be offered information, education, support and training throughout all phases of post-stroke recovery in order to enable safe discharge and successful reintegration into the community Patient, family and caregiver education is provided both formally and informally, with consideration given to individual and group settings as appropriate	AHA ESAP Au Ca	IIb A Strong (Evidence Level A).	Same Same for all	Same	Same
RECOMMENDATIONS: REFERRAL TO COMMUNITY RESOURCES					
It is recommended that acute care hospitals and rehabilitation facilities maintain up-to-date inventories of community resources	AHA	I C	Same for all		
Patient and family/caregiver preferences for resources should be considered	AHA	I C	Same for all	Same	Same
It is recommended that information about local resources be provided to the patient and family	AHA	I C	Same for all	Same	Same
It is recommended that contact with community resources be offered through formal or informal referral	AHA	I C	Same for all	Same	Same
Follow-up is recommended to ensure that the patient and family receive the necessary services	AHA	I C	Same for all	Same	Same
Patients with stroke receiving comprehensive ADL, IADL, and mobility assessments, including evaluation of the discharge living setting, should be considered candidates for community or home-based rehabilitation when feasible. Exclusions include individuals with stroke who require daily nursing services, regular medical interventions, specialized equipment, or interprofessional expertise	AHA	. I A	Same for all	Same	Same
Comprehensive discharge care plans that address the specific needs of the stroke survivor should be developed in conjunction with the stroke survivor and carer prior to discharge	Au	Strong	Same for all	Same	Same
People with stroke, including those living in a care home, should be offered a structured health and social care review at six months and 1 year after the stroke, and then annually	UK	Nil	Therapists and training	Training	Ensure incorporating in protocols

The review should consider whether further interventions are needed, and the person should be referred for further specialist assessment if: – new problems are present – the person's physical or psychological condition, or social environment has changed					
It is reasonable that caregivers, including family members, be involved in training and education related directly to home-based rehabilitation programs and be included as active partners in the planning and implementation or treatment activities under the supervision of professionals	AHA	IIa B	Therapists and caregivers	Availability of caregivers	Same
RECREATIONAL AND LEISURE ACTIVITY					
It is reasonable to promote engagement in leisure and recreational pursuits, particularly through the provision of information on the importance of maintaining an active and healthy lifestyle	AHA	IIa B	Same	Same	Same
It is reasonable to foster the development of self-management skills for problem solving for overcoming barriers to engagement in active activities	AHA	IIa B	Same	Same	Same
It is reasonable to start education and self-management skill development about leisure/ recreation activities during and in conjunction with in-patient rehabilitation It has been demonstrated that therapy to learn/re-learn leisure or social activities at home, such as gardening or painting, have a favourable effect on the participation in leisure time activities of patients with a stroke. (Level 1) Studied for ER. People with stroke should be asked about their pre-stroke work and leisure activities People with stroke who wish to return to or take up a leisure activity should have their cognitive and practical skills assessed and receive support to pursue their activity	AHA Ne UK	IIa B Level 1 Nil	Same Same	Same Same	Same Same
All patients and caregivers should receive information about the potential cognitive and emotional consequences, including fatigue, following stroke because it improves patients' and caregivers' knowledge and reduces the level of depression in patients	WFRN	LoE: 1a QoE: low SoR: B+ [clinical relevance]			
Clinicians should be aware of the influence of post-stroke fatigue on daily life functioning and societal participation. Although evidence is limited, psychosocial treatment and physical activity seem promising for the management of post-stroke fatigue	WFNR	LoE: 5 QoE: very low SoR: 0			
Cognitive problems may arise at a later stage when the patient is discharged home and environmental demands are increasing. Resuming to prior activities, especially returning to work, may lead to problems which were not detected earlier. Patients and caregivers should be referred to relevant follow-up care and neuropsychological rehabilitation within their stroke service	WFNR	LoE: 5 QoE: very low SoR: B+ [clinical relevance]			
New problems may occur in the chronic phase after stroke when environmental demands are changing or increasing. Chronicity does not necessarily imply stability. Neuropsychological rehabilitation can be offered by experienced clinical or neuropsychologists working within a multidisciplinary team in which occupational therapists will address the link to the patient's daily life functioning and societal participation	WFNR	LoE: 5 QoE: very low SoR: 0			
RECOMMENDATIONS: RETURN TO WORK Vocationally targeted therapy or vocational rehabilitation is reasonable for individuals with stroke considering a return to work People who wish to return to work after stroke (paid or unpaid employment) should:	AHA ESAP UK	IIa C Nil	Therapists, assessment centers Same for all	Lack of assessment services in many countries	WSO implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke

– have their work requirements established with their employer (provided the person with stroke agrees) – be assessed cognitively, linguistically and practically to establish their potential for return – be advised on the most suitable time and way to return to work, if return is feasible – be referred through the job center to a specialist in employment for people with disability if extra support or advice is needed – be referred to a specialist vocational rehabilitation team if the job center specialist is unable to provide the necessary rehabilitation Vocational rehabilitation programs for people after stroke should include: .- assessment of potential problems in returning to work, based on the work role and demands from both the employee's and employer's perspectives -an action plan for how problems may be overcome -interventions specifically designed for the individual which may include vocational counselling and coaching, emotional support, adaptation of the working environment -strategies to compensate for functional limitations in mobility and arm function, and fatigue management -clear communication between primary and secondary care teams and including the person with stroke, to aid benefit claims or to support a return to work					rehabilitation services to all eligible stroke patients in their countries and regions
Psychoeducation and strategy training can easily be combined in low-intensity group-based programs aimed at individualized patient-centred goals. Regional low-frequency or national high-intensity (holistic) outpatient neuro-psychological rehabilitation programs may be indicated because of the complex interplay between cognitive, emotional and social consequences. There is no time limit to these programs which means that patients may also be supported many years after the injury	WFNR	LoE: 5 QoE: very low SoR: B+ [clinical relevance]			
Psychoeducation should always be offered to both prevent and reduce anxiety, stress and depressive complaints in both patients and caregivers	WFNR	LoE: 1a QoE: moderate SoR: B+			
RECOMMENDATIONS: RETURN TO DRIVING Individuals who appear to be ready to return to driving, as demonstrated by successful performance on fitness-to-drive tests, should have an on-the-road test administered by an authorized person	AHA	IIa B	Infrastructure and personnel of road transport department	Non availability of fitness to drive assessment	Ensure availability
If the outcome of the screening shows concerns, the patient should be referred for a comprehensive fitness-to-drive assessment with a driving rehabilitation specialist, if available	WFNR	LoE: 1a QoE: moderate SoR: B+			
Determine that the patient meets the jurisdiction's minimum requirement for driving (if any)	WFNR	LoE: NA QoE: NA SoR: A+			
If there are specific requirements for driving after stroke in the jurisdiction, refer to it and ensure the patient meets the requirements	WFNR	LoE: NA QoE: NA SoR: A+			
If the patient is found unfit to drive, alternative transportation methods should be discussed with the patient	WFNR	LoE: 5 QoE: very low SoR: A+ [clinical relevance]			

If the patient does not meet one or more of the jurisdiction's prescribed requirements, the patient should be advised to allow more time for better recovery and/or discuss alternative transportation methods	WFNR	LoE: 5 QoE: very low SoR: A+ [clinical relevance]			
Red flags ought first to be assessed, i.e., risk of recurring stroke, risk of epileptic seizures or severe neglect etc	WFNR	LoE: 5 QoE: very low SoR: A+ [clinical relevance]			
Adequate screening tools should be used to determine patients whose functional deficit(s) is(are) reason(s) for concerns	WFNR	LoE: 1a QoE: moderate SoR: B+			
If driving-specific rehabilitation is warranted, contextual training in a driving simulator is preferred for maximum generalization of benefit, although non-contextual training has also shown moderate benefit	WFNR	LoE: 1a QoE: low (imprecision, inconsistency) SoR: B+ [clinical relevance]			
Retraining can also be offered in the form of lessons with a driving instructor in a dual controlled vehicle	WFNR	LoE: 4 QoE: very low SoR: 0			
The off-road part of the fitness-to-drive assessment ought to include tests of monocular and binocular visual acuities and visual field; cognitive testing to ascertain general cognitive status also needs to be done; finally, basic motor testing of strength, coordination, and range of motion should be assessed. However, there is no consensus on the selection of tests to include in the assessment	WFNR	LoE: 5 QoE: very low SoR: A+ [clinical relevance]			
If the outcome of the off-road assessment shows some, but no serious concern, the patient should be referred for a practical on-road test (if available) to confirm the suitability to resume driving with or without restrictions	WFNR	LoE: 5 QoE: very low SoR: B+ [clinical relevance]			
It is reasonable that individuals be assessed for cognitive, perception, physical, and motor abilities to ascertain readiness to return to driving according to safety and local laws Do not assess driving eligibility with cognitive tests if the person's language impairment would invalidate the results Do refer for an on-road assessment if there is uncertainty about eligibility for driving	AHA UK	IIa B Nil	Same Same	Same Same	Same Same
It is reasonable that individuals who do not pass an on-the-road driving test be referred to a driver rehabilitation program for training	AHA	I C IIa B	Same	Same	Same
Sex People with stroke should be asked, soon after discharge and at their 6-month and annual reviews, whether they have any concerns about sex. Partners should also have an opportunity to raise any problems. B People with sexual dysfunction after stroke who want further help should be: – assessed for treatable causes including a medication review	UK	Nil	Therapists and training	Neglected aspect of stroke rehabilitation; raise awareness	Ensure implementation in rehabilitation protocols

– reassured that sexual activity is not contraindicated after stroke and is extremely unlikely to precipitate a further stroke – assessed for erectile dysfunction and the use of a phosphodiesterase type 5 inhibitor (e.g., sildenafil) – advised against the use of a phosphodiesterase type 5 inhibitor for 3 months after stroke and/or until blood pressure is controlled – referred to a professional with expertise in psychosexual problems if sexual dysfunction persists

AHA: American Hypertension Association. ESAP: European Stroke Action Plan. Ca: Canada. Au: Australia. UK: United Kingdom. Ne: The Netherlands. American Heart Association (e.g., Class I Level A),[4] Netherlands KNGF Stroke Guideline,[5] Canada Stroke Best Practice recommendation,[7] Clinical pathways in stroke rehabilitation: evidence-based clinical practice recommendations[55] European Stroke Organisation,[8] Australian Stroke Foundation[9], United Kingdom NICE guideline for stroke,[10] and World Stroke Organization.[151]

Supplementary Table 21. Summary of key pragmatic solutions based on national and international stroke guidelines to improve stroke rehabilitation services worldwide

KEY RECOMMENDATIONS (Criteria: Class I and III and IIa A or B, IIbA recommendations only from best Guidelines reviewed based on COUNCIL Criteria)	**Source**	**LOE**	**Resources required for implementation**	**Barriers/Facilitators for implementation in LMICs**	**Pragmatic Solutions/Recommendation** for contextualization and implementation in LMICs through implementation ecosystem
ORGANIZATION OF REHABILITATION SERVICE					
It is recommended that early rehabilitation for hospitalized stroke patients be provided in environments with organized, interprofessional stroke care.	AHA ESAP	I A	Multidisciplinary rehabilitation facilities with rehabilitation doctor/physician/neurologist, physiotherapist, occupational therapist, speech and language and dysphagia therapist, clinical psychologist, nurse; etc.	Major barriers to be surmounted include lack of awareness and low demand, absence of/or inadequate number of rehabilitation professionals (need to establish training institutions/program to produce adequate number of professionals); need to adapt evidence-base practice recommendations to regional capacities (need to establish regional protocols / clinical pathways); need to finance rehabilitation services to make them accessible and available to all stroke patients	Implementation ecosystem on Stroke commissioners to develop, implement and monitor strategic action plan with all stakeholders to ensure availability of stroke rehabilitation services to all eligible stroke patients in their countries and regions

SKIN					
In ischaemic stroke, prophylactic-dose subcutaneous heparin (UFH or LMWH) should be used for the duration of the acute and rehabilitation hospital stay or until the stroke survivor regains mobility	AHA	I A	Subcutaneous heparin	Availability of subcutaneous heparin	Provision and administration of subcutaneous Heparin for DVT prophylaxis in patients with ischaemic stroke
PAIN					
Patient and family education (i.e., range of motion, positioning) is recommended for shoulder pain and shoulder care after stroke, particularly before discharge or transitions in care	AHA	I C	Education	Education	Training of care providers to educate patients/family members
FALLS					
It is recommended that individuals with stroke be provided a formal fall prevention program during hospitalization People with stroke should be offered falls risk assessment and management as part of their stroke rehabilitation, including training for them and their family/carers in how to get up after a fall People with stroke should be offered an assessment of fear of falling as part of their falls risk assessment People at high risk of falls after stroke should be offered a standardized assessment of fragility fracture risk as part of their stroke rehabilitation People with stroke with symptoms of vitamin D deficiency, or those who are considered to be at high risk (e.g., housebound) should be offered calcium and vitamin D supplements People at high risk of falls after stroke should be advised to participate in physical activity/exercise which incorporates balance and co-ordination at least twice per week	AHA UK	I A Nil	In hospital rehabilitation programs with balance and falls risk assessment	Limited number of organized programs with assessment of balance and risk falls	Support for workshops, production of free online training materials
DEPRESSION					
In the first months post-stroke, antidepressant pharmacotherapy is only recommended if the process of rehabilitation is hindered by emotional problems. Increasing motivation for and participation in rehabilitation is the target for treatment. Selective serotonin reuptake inhibitors, SSRIs should be considered when depressive complaints or	WFNR	LoE: 1a QoE: moderate SoR: B+			

emotionalism are long lasting and become chronic while adverse effects should be monitored continuously					
CONSCIOUSNESS					
Amantadine for a course of amantadine treatment over a couple of weeks can be used in the beginning of the rehabilitation treatment of stroke survivors with DoC (VS-MCS) to promote recovery in the disability domain The evidence is too limited to guide clinical decision-making with respect to long-term use and discontinuation of amantadine, or the prescription of other drugs to treat DoC in stroke survivors	WFNR	LoE: 1b QoE: moderate SoR: 0 indirectness of evidence			
COGNITION					
Screening for cognitive deficits is recommended for all stroke patients before discharge home When screening reveals cognitive deficits, a more detailed neuropsychological evaluation to identify areas of cognitive strength and weakness may be beneficial Services for people with stroke should have a comprehensive approach to delivering psychological care that includes specialist clinical neuropsychology/clinical psychology input within the multi-disciplinary team People with stroke should be considered to have at least some cognitive impairment in the early phase. Routine screening should be undertaken to identify the person's level of functioning, using standardized measures People with communication impairment after stroke should receive a cognitive assessment using valid assessments in conjunction with a speech and language therapist. Specialist advice should be sought if there is uncertainty about the interpretation of cognitive test results Any person with stroke who is not progressing as expected in rehabilitation should receive a detailed assessment to determine whether cognitive impairments are responsible, with the results explained to the person, their family, and the multidisciplinary team People with acute cognitive problems after stroke whose care is being transferred from hospital should receive an assessment for any safety risks from persisting cognitive	AHA AHA UK Nil	I B IIa C	Multidisciplinary approach should include trained clinical psychologist experienced in cognitive assessment (neuropsychologist)	Limited number of trained neuropsychologists /occupational therapists	Need to finance multidisciplinary rehabilitation including neuropsychologists/ occupational therapists

impairments. Risks should be communicated to their primary care team together with any mental capacity issues that might affect their decision-making People with stroke returning to cognitively demanding activities such as driving, or work should have their cognition fully assessed					
DYSPHAGIA SCREENING, MANAGEMENT, AND NUTRITIONAL SUPPORT					
Early dysphagia screening is recommended for acute stroke patients to identify dysphagia or aspiration, which can lead to pneumonia, malnutrition, dehydration, and other complications	AHA Au	I B Strong	Multidisciplinary approach should include trained speech and swallowing therapist	Limited number of trained speech and swallowing therapist	Financing training program, workshops, and online materials for healthcare provider
External feedings (tube feedings) should be initiated within 7 days after stroke for patients who cannot safely swallow	AHA	I A	Implementation of a dysphagia screening program for all stroke cases	Major barriers to be surmounted include lack of awareness and low demand, absence of/or inadequate number of professionals	Financing training program, workshops and online materials for healthcare provider
APHASIA					
Recommendations: Aphasia Speech and language therapy is recommended for individuals with aphasia People with communication problems after stroke should be assessed by a speech and language therapist to diagnose the problem and to explain the nature and implications to the person, their family/careers and the multidisciplinary team. Reassessment in the first four months should only be undertaken if the results will affect decision-making or are required for mental capacity assessment People with communication problems after stroke should be assessed by a speech and language therapist to diagnose the problem and to explain the nature and implications to the person, their family/careers and the multidisciplinary team. Reassessment in the first four months should only be undertaken if the results will affect decision-making or are required for mental capacity assessment	AHA Au UK WFNR	I A Strong Nil	Multidisciplinary approach should include trained speech and language therapists	Limited number of trained speech and language therapists	Financing training program, workshops and online materials for healthcare provider
SPASTICITY					
Targeted injection of botulinum toxin into localized upper limb muscles is recommended to reduce spasticity, to improve passive or active range of motion, and to improve dressing, hygiene, and limb positioning	AHA	I A	Multidisciplinary approach should	Limited number of trained neurologists //physical and	Financing training programs, workshops, and

			include trained neurologists for Botox injection	rehabilitation medicine doctors	online materials for neurologists/physical and rehabilitation medicine doctors
BALANCE					
Individuals with stroke who have poor balance, low balance confidence, and fear of falls or are at risk for falls should be provided with a balance training program For patients with balance disorders post stroke, balance training should be offered It has been demonstrated that exercising postural control with visual feedback while standing on a force platform improves the postural sway in stance of patients with a stroke Studied for early and chronic rehabilitation It has been demonstrated that exercising balance during various activities results in improved sitting and standing balance and improved performance of basic activities of daily living by stroke patients Studied for early, late, and chronic rehabilitation	AHA Ca Ne	I A Evidence Level A (Level 1)	Physiotherapists are required for balance training	Need large number of physiotherapists	Recommend training of more physiotherapists for stroke patients globally
MOBILITY					
Intensive, repetitive, mobility- task training is recommended for all individuals with gait limitations after stroke Task and goal-oriented training that is repetitive and progressively adapted should be used to improve performance of selected lower-extremity tasks such as walking distance and speed and sit to stand It has been demonstrated that training specific skills, such as exercising balance while standing and reaching to grasp objects, has a favorable effect on the specific skill being trained by stroke patients in all phases of rehabilitation People with loss of movement and/or ataxia after stroke sufficient to limit their activities should be assessed by a physiotherapist with experience in neurological rehabilitation People with loss of movement and/or ataxia after stroke should be taught task-specific, repetitive, intensive exercises or activities that will increase strength	AHA Ca ESAP Ne UK	I A Evidence Level A Level 1 Nil	Physiotherapists are required for mobility and gait training	Need large number of physiotherapists/ physical and rehabilitation medicine doctors	Recommend training of more physiotherapists /physical and rehabilitation medicine doctors for stroke patients globally

People with impaired sitting balance after stroke should receive trunk training exercises People with significant impairment of their balance and walking ability after stroke should receive progressive balance training, functional task-specific training, lower limb strengthening exercises and be considered for an ankle-foot orthosis People with moderate to severe limitation of their walking ability after stroke should be assessed for a walking aid to improve their stability People with stroke who are able to walk with or without assistance should undergo task specific walking training with a cardiorespiratory and/or muscle strength focus at sufficient intensity to improve endurance and walking speed People with limited ability to walk after stroke should be assessed by a physiotherapist with experience in neurological rehabilitation to guide management People with limited mobility after stroke should be assessed, provided with and trained in how to use appropriate mobility aids including a wheelchair to enable safe independent mobility					
UPPER EXTREMITY ACTIVITY, INCLUDING ADLS, IADLS, TOUCH, AND PROPRIOCEPTION					
Functional tasks should be practiced: that is, task-specific training, in which the tasks are graded to challenge individual capabilities, practiced repeatedly, and progressed in difficulty on a frequent basis Patients should engage in training that is meaningful, engaging, repetitive, progressively adapted, task specific and goal-oriented in an effort to enhance motor cont11rol and restore sensorimotor function ii. Training should encourage the use of patients' affected limb during functional tasks and be designed to simulate partial or whole skills required in activities of daily living (e.g., folding, buttoning, pouring, and lifting) The team should promote the practice and transfer of skills gained in therapy into the patient's daily routine Therapy should include repetitive and intense use of novel tasks that challenge the patient to acquire the necessary skills needed to perform functional tasks and activities (Evidence Level A) People with stroke with potential or actual arm movement should be given every opportunity to practice functional activities. Practice should be characterized by	AHA Ca UK	I A (Evidence Level A), Nil	Therapists, training Same for all	Availability of therapists	Ensure incorporation in stroke rehabilitation protocols

movements that are of high intensity, repetitive and are task-specific. These activities may be bilateral or unilateral depending on the task					
CHRONIC CARE MANAGEMENT: HOME- AND COMMUNITY-BASED PARTICIPATION					
After completion of formal stroke rehabilitation, participation in a program of exercise or physical activity at home or in the community is recommended. (Access to green areas and walking space may facilitate physical activity) Community-dwelling stroke survivors who have difficulties performing daily activities should be assessed by a trained clinician Community-dwelling stroke survivors with confirmed difficulties in personal or extended ADL should have specific therapy from a trained clinician (e.g., task-specific practice and training in the use of appropriate aids) to address these issues	AHA ESAP Au	I A Strong	Therapists and training	Training	Same
TREATMENTS/INTERVENTIONS FOR VISUAL IMPAIRMENTS					
For deficits in eye movements: Eye exercises for treatment of convergence insufficiency are recommended	AHA	I A	Therapists and training	Training	Ensure incorporating in protocols
SOCIAL AND FAMILY CAREGIVER SUPPORT					
It may be useful for the family/caregiver to be an integral component of stroke rehabilitation	AHA ESAP	IIb A	Therapists and caregivers	Training and availability of caregivers	Ensure implementation
REFERRAL TO COMMUNITY RESOURCES					
It is recommended that acute care hospitals and rehabilitation facilities maintain up-to-date inventories of community resources	AHA	I C	Therapists and caregivers	Training and availability of caregivers	Ensure implementation
RECREATIONAL AND LEISURE ACTIVITY					
It is reasonable to promote engagement in leisure and recreational pursuits, particularly through the provision of information on the importance of maintaining an active and healthy lifestyle	AHA	IIa B	Therapists and caregivers	Training and availability of caregivers	Ensure implementation

American Heart Association (e.g., Class I Level A)[82], Netherlands KNGF Stroke Guideline[83], Canada Stroke Best Practice recommendation[84], WFNR Clinical pathways in stroke rehabilitation: evidence-based clinical practice recommendations[85], European Stroke Organisation, Australian Stroke Foundation[2], United Kingdom NICE guideline for stroke[86], and World Stroke Organization. AHA: American Hypertension Association. ESAP: European Stroke Action Plan. Ca: Canada. Au: Australia. UK: United Kingdom. Ne: The Netherlands.

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