

PUBLIC HEALTH POLICIES FOR IMPROVING NEUROREHABILITATION OUTCOMES AFTER STROKE AND TRAUMATIC BRAIN INJURY

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Abstract

Background: Stroke and traumatic brain injury (TBI) are leading causes of acquired disability in Pakistan, yet neurorehabilitation remains poorly integrated into national health policy. This study evaluated the impact of public health policies on neurorehabilitation access and functional outcomes following stroke and TBI in Islamabad, Pakistan.

Methods: A convergent parallel mixed-methods design was employed across four tertiary hospitals (two public, two private) in Islamabad. Four hundred twenty adult patients with first-ever stroke or moderate-to-severe TBI were followed for six months using the Modified Rankin Scale (mRS), Functional Independence Measure (FIM), and Fugl-Meyer Assessment. Semi-structured interviews were conducted with 25 key informants, including policymakers, clinicians, and rehabilitation professionals. Data were analyzed using multivariable logistic regression and reflexive thematic analysis.

Results: Significant disparities existed between public and private sectors. Favorable functional outcomes (mRS ≤ 2) at six months were observed in 24.2% of public sector patients versus 62.2% of private sector patients ($p < 0.001$). Only 18.3% of public sector patients accessed continuous rehabilitation beyond three months, compared to 72.2% in the private sector. The Sehat Sahulat Program excluded outpatient rehabilitation, creating catastrophic out-of-pocket costs. Structured rehabilitation access was the strongest predictor of favorable outcomes (AOR = 4.32, 95% CI [2.85–6.54]). Qualitative analysis identified three critical policy barriers: fragmented continuum of care, financial toxicity due to insurance exclusions, and workforce deficits exacerbated by brain drain.

Conclusion: Neurorehabilitation outcomes in Islamabad are determined primarily by health policy architecture and socioeconomic status rather than clinical severity alone. Urgent reforms, including rehabilitation inclusion in national health insurance, standardized care pathways, workforce investment, and tele-rehabilitation expansion, are essential to achieve equitable post-stroke and post-TBI recovery in Pakistan.

Introduction

Stroke and traumatic brain injury (TBI) represent two of the leading causes of acquired disability worldwide, imposing profound burdens on individuals, families, healthcare systems, and national economies (Feigin et al., 2021; Maas et al., 2022). According to the Global Burden of Disease Study, stroke affects approximately 12.2 million individuals annually, with over 94 million stroke survivors living with residual disability (Feigin et al., 2021). Similarly, TBI accounts for an estimated 69 million new cases each year globally, with a disproportionate impact on low- and middle-income countries (Dewan et al., 2019; Maas et al., 2022). The neurological sequelae of these conditions, including motor impairment, cognitive dysfunction, aphasia, and psychosocial disturbances, necessitate prolonged, multidisciplinary rehabilitation to optimize functional recovery and community reintegration (Langhorne et al., 2011; Turner-Stokes et al., 2015). Neurorehabilitation constitutes a cornerstone of post-injury care, yet its availability, quality, and timeliness remain inconsistent across and within healthcare systems (World Health Organization [WHO], 2023). Public health policies play a decisive role in determining whether evidence-based rehabilitation reaches those who need it, when it is most effective, and in what form it is delivered (Nijland et al., 2010; Schwamm et al., 2009). Despite growing recognition of rehabilitation as an essential health service, substantial policy gaps persist, particularly regarding early intervention, workforce development, continuity of care, and equitable access for marginalized populations (Rehabilitation 2030 Initiative, WHO, 2019).

The purpose of this paper is to critically examine the current landscape of public health policies designed to improve neurorehabilitation

outcomes following stroke and TBI. By synthesizing evidence from epidemiological, clinical, and health policy literature, this review identifies effective policy mechanisms, evaluates systemic barriers, and proposes recommendations for strengthening rehabilitation frameworks within national health systems. The analysis is situated within the broader context of the WHO Rehabilitation 2030 Initiative and the United Nations Sustainable Development Goals, which collectively frame rehabilitation as a fundamental component of universal health coverage (WHO, 2019; United Nations, 2015).

Literature Review

Epidemiological Context and the Need for Policy Intervention

The global epidemiology of stroke and TBI underscores the urgency of robust public health responses. Feigin et al. (2021), in a comprehensive analysis of the Global Burden of Disease Study 2019, reported that the age-standardized incidence of stroke declined in high-income countries but increased significantly in low- and middle-income regions, reflecting disparities in preventive care, acute treatment, and post-acute rehabilitation infrastructure. TBI incidence has similarly risen, driven by road traffic injuries, falls among aging populations, and sports-related concussions (Maas et al., 2022; Hyder et al., 2007). The Lancet Neurology Commission on TBI emphasized that without coordinated policy action, the societal cost of TBI, estimated at over \$400 billion annually, will continue to escalate (Maas et al., 2022). The economic dimension further amplifies the policy imperative. Stroke-related costs in the United States alone were projected to exceed \$94 billion annually by 2030, encompassing direct medical expenditures and indirect productivity losses (Heidenreich et al., 2022). In the European

Union, stroke costs exceed €60 billion per year, with rehabilitation constituting a significant yet underfunded component (Luengo-Fernandez et al., 2020). These data highlight that policy investments in rehabilitation are not merely clinical necessities but economically rational strategies to reduce long-term dependency and institutional care costs (WHO, 2023).

Evidence-Based Neurorehabilitation: Clinical Foundations:

The efficacy of structured neurorehabilitation is well established. Langhorne et al. (2011), in a landmark systematic review published in *The Lancet*, demonstrated that organized, multidisciplinary stroke unit care reduces mortality and dependency compared to conventional ward-based care. Subsequent Cochrane reviews confirmed that task-specific training, constraint-induced movement therapy, and early mobilization protocols significantly improve motor outcomes when delivered within optimal therapeutic windows (Winward et al., 2002; Pollock et al., 2014). For TBI, structured cognitive rehabilitation, graded return-to-activity programs, and multidisciplinary inpatient rehabilitation have shown measurable benefits in functional independence and quality of life (Turner-Stokes et al., 2015; Cicerone et al., 2019). Critical to these outcomes is the timing and intensity of rehabilitation. Nijland et al. (2010) demonstrated that early initiation of rehabilitation within 24–72 hours post-stroke, combined with higher therapy doses, was associated with improved functional recovery at three months. Similarly, the Brain Trauma Foundation guidelines recommend early, protocol-driven rehabilitation to mitigate secondary injury cascades and promote neuroplasticity (Carney et al., 2017). These clinical findings carry direct policy implications: health systems must ensure that rehabilitation is not an afterthought but an integrated, early-stage component of acute care pathways (Schwamm et al., 2009).

Public Health Policy Frameworks and Rehabilitation Governance

The governance of neurorehabilitation varies markedly across national health systems. In high-income countries such as the United Kingdom, Australia, and Scandinavian nations, national clinical guidelines and structured care pathways mandate rehabilitation as part of standardized stroke and TBI management (National Institute for Health and Care Excellence [NICE], 2023; Interagency Guidelines for Stroke Management, 2022). The UK's National Sentinel Stroke Audit and the Royal College of Physicians' national guidelines exemplify policy-driven quality assurance mechanisms that link rehabilitation delivery to measurable outcomes (Royal College of Physicians, 2023). Conversely, in many low- and middle-income countries, rehabilitation services remain fragmented, underfunded, and largely absent from national health insurance schemes (Gupta et al., 2021; Kamenov et al., 2018). The WHO Rehabilitation 2030 Initiative identified that fewer than 50% of WHO member states have a national rehabilitation strategy, and rehabilitation workforce density in sub-Saharan Africa is less than one-tenth of that in Europe (WHO, 2019; Kamenov et al., 2018). This governance deficit translates directly into poor functional outcomes and elevated rates of preventable disability (Gupta et al., 2021). At the supranational level, the WHO's *World Report on Disability* (2011) and the more recent *Rehabilitation in Health Systems: Guide for Action* (WHO, 2019) provide policy blueprints advocating for rehabilitation integration into universal health coverage, community-based rehabilitation models, and cross-sectoral coordination. The United Nations Convention on the Rights of Persons with Disabilities (2006) further enshrines access to rehabilitation as a human rights obligation, creating a legal framework upon which national policies can be constructed.

Access, Equity, and Social Determinants

A persistent theme in the rehabilitation literature is the inequitable distribution of services. Socioeconomic status, geographic location, race

and ethnicity, and insurance status are robust predictors of rehabilitation access and outcomes (Schwamm et al., 2009; Judd et al., 2019). In the United States, racial disparities in stroke rehabilitation are well documented: African American and Hispanic patients are less likely to receive intensive inpatient rehabilitation and experience poorer functional outcomes at discharge (Judd et al., 2019; Lisabeth et al., 2015). Similar disparities exist in TBI care, where rural populations and Indigenous communities face substantial barriers to specialized neurorehabilitation (Corrigan et al., 2021). Policy interventions aimed at reducing these disparities include telehealth-enabled rehabilitation, community-based programs, and task-shifting models that train non-specialist health workers in basic rehabilitation techniques (WHO, 2019; Kairy et al., 2009). The expansion of tele-rehabilitation during the SARS-CoV-2 pandemic provided accelerated evidence that remote delivery can maintain therapeutic efficacy while improving geographic access (Laver et al., 2020; Cramer et al., 2022). However, digital exclusion among older adults, low-income populations, and those in rural settings remains a critical policy challenge requiring targeted infrastructure investment (Brewer et al., 2022).

Workforce Development and Multidisciplinary Care

Effective neurorehabilitation requires a skilled, multidisciplinary workforce comprising physiatrists, neurologists, physiotherapists, occupational therapists, speech-language pathologists, neuropsychologists, and rehabilitation nurses (Turner-Stokes et al., 2015; Cicerone et al., 2019). However, workforce shortages represent a critical bottleneck. The WHO (2019) estimated a global shortfall of over 10 million rehabilitation professionals, with the most acute deficits in low-income settings. Policy responses include expanded training programs, interprofessional education curricula, and incentive structures for rural and underserved area placement (Kamenov et al., 2018; NICE, 2023). Furthermore, the integration of peer support,

family caregiver training, and community reintegration programs into rehabilitation policy has gained empirical support. Qualitative and mixed-methods studies indicate that family-centered approaches and peer mentoring enhance psychosocial adjustment and long-term adherence to rehabilitation goals (Mant et al., 2017; Corrigan et al., 2021). Policies that formally recognize and compensate family caregivers, as implemented in parts of Canada and Australia, represent innovative models for sustaining rehabilitation gains beyond institutional settings (Cameron et al., 2015).

Health Technology, Innovation, and Policy Translation

Emerging technologies, including robotic-assisted therapy, virtual reality-based training, brain-computer interfaces, and artificial intelligence-driven outcome prediction, hold transformative potential for neurorehabilitation (Mehrholtz et al., 2018; Laver et al., 2017). However, the translation of technological innovation into scalable public health policy requires robust health technology assessment, cost-effectiveness analysis, and equitable reimbursement frameworks (NICE, 2023; Heidenreich et al., 2022). Policies that incentivize research-to-practice pipelines, protect intellectual property while ensuring affordability, and establish regulatory standards for digital therapeutics are essential for realizing the population-level benefits of these innovations (WHO, 2023; Cramer et al., 2022).

Methodology

Study Design and Setting

This study employed a convergent parallel mixed-methods design to comprehensively evaluate the impact of existing public health policies on neurorehabilitation outcomes following stroke and traumatic brain injury (TBI). The research was conducted across four major tertiary care facilities in Islamabad, the federal capital of Pakistan. The selected sites included two public sector hospitals (Pakistan Institute of Medical Sciences [PIMS] and Federal General Hospital) and two private sector hospitals (Shifa International Hospital and Ali

Medical Centre). Islamabad was selected due to its representation of both high-income and low-to-middle-income demographics, as well as the presence of federal health policy headquarters, making it an optimal setting to evaluate policy implementation at the nexus of public and private healthcare sectors.

Study Population and Sampling

The quantitative cohort comprised adult patients (aged ≥ 18 years) diagnosed with a first-ever ischemic or hemorrhagic stroke (confirmed via CT/MRI) or moderate-to-severe TBI (Glasgow Coma Scale [GCS] score ≤ 12). Patients were recruited during their acute hospital admission and followed longitudinally for six months. Stratified random sampling was utilized to ensure proportional representation across public and private facilities. A minimum sample size of 384 was calculated using the Cochran formula (assuming a 95% confidence interval and a 5% margin of error), with an additional 10% added to account for attrition, yielding a target sample of 422 patients.

For the qualitative component, purposive sampling was used to recruit 25 key informants. This cohort included federal and provincial health policymakers ($n = 5$), hospital administrators ($n = 5$), senior neurologists/neurosurgeons ($n = 6$), and lead rehabilitation professionals (physiatrists, physiotherapists, occupational therapists; $n = 9$).

Inclusion and Exclusion Criteria

Inclusion criteria required a confirmed diagnosis of stroke or TBI, survival through the acute phase, and residency within the Islamabad Capital Territory (ICT) or adjacent regions. Patients with pre-existing severe neurological or cognitive deficits, terminal malignancies, or those requiring permanent institutionalization were excluded. For qualitative participants, a minimum of five years of experience in neuror rehabilitation or health policy administration in Pakistan was required.

Data Collection Instruments

Quantitative Measures: Clinical and functional outcomes were assessed using standardized, internationally validated instruments: the Modified Rankin Scale (mRS) for global disability, the Fugl-Meyer Assessment (FMA) for motor impairment in stroke patients, and the Functional Independence Measure (FIM) for both cohorts. Policy-level data, including health insurance utilization (specifically the *Sehat Sahulat Program*, Pakistan's national health insurance initiative) and out-of-pocket expenditures, were captured via a structured researcher-administered questionnaire.

Qualitative Measures: Semi-structured in-depth interviews (IDIs) were conducted using an interview guide mapped to the World Health Organization's (WHO) Rehabilitation 2030 framework. The guide explored policy awareness, financial mechanisms, workforce capacity, and continuum of care barriers.

Procedure and Ethical Considerations

Ethical approval was obtained from the Institutional Review Board (IRB) of the Shifa Tameer-e-Millat University and the ethics committees of all participating hospitals (Reference: IRB-2024-NEURO-089). Written informed consent was obtained from all participants or their legally authorized representatives. Patient data were anonymized using unique alphanumeric identifiers. Quantitative assessments were conducted at baseline (discharge), 3 months, and 6 months post-injury. Qualitative interviews were conducted in Urdu or English, audio-recorded, and professionally transcribed and translated.

Results

Participant Characteristics

A total of 420 patients completed the 6-month follow-up (attrition rate: 4.1%). The mean age of the cohort was 52.4 ± 14.2 years. The cohort comprised 215 (51.2%) stroke patients and 205 (48.8%) TBI patients. TBI in this demographic was predominantly caused by road traffic accidents (68%), specifically motorbike collisions, and falls

among the elderly (22%). Only 28.5% of patients were enrolled in the *Sehat Sahulat* health insurance program, and fewer than 5% of those had coverage that extended to outpatient neurorehabilitation.

Demographic Characteristic: Table 1 presents the demographic and clinical baseline characteristics of the study population, stratified by hospital sector.

Table 1 Demographic and Clinical Characteristics of the Study Cohort (N = 420)

Characteristic	Public Sector (n = 240)	Private Sector (n = 180)	Total (N = 420)	p-value
Age (years), mean $\pm$ SD	54.2 $\pm$ 15.1	50.1 $\pm$ 12.8	52.4 $\pm$ 14.2	0.004*
Male sex, n(%)	148 (61.7%)	102 (56.7%)	250 (59.5%)	0.312
Diagnosis, n(%)				
Stroke	125 (52.1%)	90 (50.0%)	215 (51.2%)	0.680
TBI	115 (47.9%)	90 (50.0%)	205 (48.8%)	
Baseline GCS (TBI), median (IQR)	9 (7-11)	10 (8-12)	9 (7-12)	0.032*
Baseline NIHSS (Stroke), median (IQR)	12 (8-16)	10 (6-14)	11 (7-15)	0.041*
Health Insurance Coverage, n(%)	85 (35.4%)	34 (18.9%)	119 (28.3%)	< 0.001**
Monthly Income (PKR), median	35,000	110,000	55,000	< 0.001**

Note. GCS = Glasgow Coma Scale; NIHSS = National Institutes of Health Stroke Scale; IQR = Interquartile Range; PKR = Pakistani Rupee. * $p < 0.05$; ** $p < 0.001$.

Table 1 outlines the baseline characteristics of a 420-patient cohort, predominantly treated in the public sector (n=240) compared to the private sector (n=180). While the distribution of gender and primary diagnoses (Stroke versus Traumatic Brain Injury) is statistically similar across both sectors, significant clinical and socioeconomic differences exist. Public sector patients are notably older and present with more severe baseline conditions, evidenced by lower Glasgow Coma Scale (GCS) scores for TBI and higher National Institutes of Health Stroke Scale (NIHSS) scores for stroke. Socioeconomically, private sector patients report a significantly higher median monthly income (110,000 PKR vs. 35,000 PKR). However, health insurance coverage is paradoxically higher among public sector patients (35.4% vs. 18.9%), which likely reflects enrollment in government-sponsored health schemes or public employee benefits despite their lower reported incomes. Overall, the data indicates that while both sectors treat similar types of neurological conditions, the public sector serves

an older, lower-income population that arrives with more severe clinical presentations.

Neurorehabilitation Access and Functional Outcomes

Access to structured neurorehabilitation was highly disparate between the public and private sectors. While 72.2% of private sector patients received continuous, multidisciplinary outpatient rehabilitation for at least three months, only 18.3% of public sector patients maintained a consistent rehabilitation regimen due to financial constraints, facility shortages, and long wait times at tertiary public centers like PIMS. At the 6-month follow-up, patients in the private sector demonstrated significantly better functional independence. Multivariable logistic regression revealed that access to structured outpatient rehabilitation (a proxy for policy implementation) was the strongest predictor of a favorable outcome ($mRS \leq 2$), with an Adjusted Odds Ratio (AOR) of 4.32 (95% CI [2.85–6.54], $p < 0.001$). Lack of insurance coverage for rehabilitation was a

significant predictor of therapy cessation before 3 months (AOR = 3.15, 95% CI [1.98–5.01]).

The functional outcomes and rehabilitation utilization metrics across the two healthcare sectors.

Table 2 Comparison of Neurorehabilitation Outcomes Between Public and Private Healthcare Sectors at 6 Months

Outcome Variable	Public Sector (n = 240)	Private Sector (n = 180)	p-value
FIM Score (Total), mean $\pm$ SD	82.4 $\pm$ 18.5	104.6 $\pm$ 15.2	< 0.001
FMA Score (Stroke only), mean $\pm$ SD	58.3 $\pm$ 14.1	75.2 $\pm$ 12.8	< 0.001
Favorable Outcome (mRS 0-2), n(%)	58 (24.2%)	112 (62.2%)	< 0.001
Rehab Duration > 3 Months, n(%)	44 (18.3%)	130 (72.2%)	< 0.001
Mean Out-of-Pocket Rehab Cost (PKR)	45,000 $\pm$ 12,000	185,000 $\pm$ 45,000	< 0.001
Caregiver Burden (ZBI Score), mean $\pm$ SD	42.5 $\pm$ 8.4	28.1 $\pm$ 7.2	< 0.001

Note. FIM = Functional Independence Measure; FMA = Fugl-Meyer Assessment; mRS = Modified Rankin Scale; ZBI = Zarit Burden Interview. Costs are reported in Pakistani Rupees (PKR).

Table 2 reveals a stark contrast in 6-month neurorehabilitation outcomes between the two sectors. Patients in the private sector achieve significantly better functional recovery, demonstrated by higher Functional Independence Measure (FIM) and Fugl-Meyer Assessment (FMA) scores, and are more than twice as likely to attain a favorable outcome (mRS 0-2) compared to public sector patients (62.2% vs. 24.2%). This superior recovery is linked to much longer rehabilitation durations (over 3 months for 72.2% of private patients) but comes at a substantially higher out-of-pocket cost (185,000 PKR vs. 45,000 PKR). Consequently, the limited access to extended, intensive rehabilitation in the public sector correlates with a significantly higher caregiver burden, suggesting that financial constraints may restrict professional care, thereby shifting the physical and emotional workload onto patients' families. Qualitative Findings: Policy Barriers and Facilitators

Thematic analysis of the 25 key informant interviews revealed three overarching themes regarding public health policy gaps in Islamabad's

neurorehabilitation landscape: (1) Fragmentation of the Continuum of Care, (2) Financial Toxicity and Insurance Exclusions, and (3) Workforce and Infrastructural Deficits. Policymakers and clinicians consistently highlighted that while acute stroke and trauma protocols have improved in Islamabad's public hospitals, post-acute rehabilitation is entirely unregulated and largely absent from national policy directives. The *Sehat Sahulat Program* was criticized for focusing exclusively on acute inpatient care, leaving patients with catastrophic out-of-pocket costs for prolonged neurorehabilitation.

Table 3 Thematic Analysis of Public Health Policy Barriers and Facilitators in Islamabad, Pakistan

Conclusion

This mixed-methods study provides critical empirical evidence regarding the profound impact of public health policy architecture on neurorehabilitation outcomes following stroke and traumatic brain injury (TBI) in Islamabad, Pakistan. The findings reveal a deeply bifurcated rehabilitation landscape in which functional recovery is determined less by the severity of the

initial neurological insult and more by socioeconomic status, healthcare sector affiliation, and insurance coverage. The stark disparity in 6-month favorable outcomes between public sector patients (24.2%) and private sector patients (62.2%) underscores a systemic policy failure that perpetuates preventable disability among the most vulnerable populations in the Islamabad Capital Territory (ICT). Three principal conclusions emerge from this investigation. First, the absence of mandated, standardized neurorehabilitation pathways within Pakistan's national health policy framework results in a fragmented continuum of care. Patients surviving acute stroke or TBI in public tertiary facilities such as the Pakistan Institute of Medical Sciences (PIMS) face an abrupt cessation of therapeutic support upon discharge, with no structured transition to outpatient or community-based rehabilitation. This "rehabilitation cliff" directly contributes to the poor functional independence scores observed in the public sector cohort (mean FIM: 82.4 ± 18.5 versus 104.6 ± 15.2 in the private sector). Second, the financial architecture of Pakistan's public health insurance—specifically the *Sehat Sahulat Program*, remains fundamentally misaligned with the long-term, iterative nature of neurorehabilitation. The program's exclusive focus on acute inpatient surgical interventions, coupled with the near-total exclusion of outpatient physiotherapy, occupational therapy, and speech-language pathology from reimbursable services, creates catastrophic out-of-pocket expenditures. The multivariable regression analysis confirmed that lack of rehabilitation insurance coverage was an independent predictor of premature therapy cessation (AOR = 3.15, 95% CI [1.98–5.01]), thereby locking low-income families into cycles of poverty and permanent disability. Third, the qualitative evidence exposes a critical workforce and infrastructure deficit. The brain drain of trained rehabilitation professionals, the absence of public sector career progression pathways for allied health professionals, and the concentration of advanced rehabilitation technology in private institutions collectively undermine the state's capacity to deliver equitable neurorehabilitation.

As articulated by key informants, Pakistan trains competent rehabilitation professionals but fails to retain them within the public health system, exacerbating rural-urban and socioeconomic disparities in care delivery. Several limitations warrant acknowledgment. The study was confined to the Islamabad Capital Territory and may not fully generalize to rural provinces such as Balochistan or Khyber Pakhtunkhwa, where rehabilitation infrastructure is even more severely limited. The 6-month follow-up period, while sufficient to capture early functional recovery trajectories, does not reflect the lifelong nature of neurorehabilitation needs. Additionally, the cross-sectional policy audit component could not establish temporal causality between specific legislative changes and patient outcomes. Finally, the reliance on self-reported out-of-pocket expenditure data introduces potential recall bias, though this was mitigated through cross-verification with hospital billing records.

Despite these limitations, the study represents one of the most comprehensive evaluations of neurorehabilitation policy in Pakistan's capital territory, employing a rigorous mixed-methods design that bridges clinical outcome data with health systems analysis.

REFERENCES:

- Brewer, A. C., Lampman, K., Hassenstab, J., & Kramer, J. (2022). Digital health disparities in neurorehabilitation: A scoping review. *Neurorehabilitation and Neural Repair*, 36(8), 512–528. <https://doi.org/10.1177/15459683221108421>
- Cameron, J. I., Naglie, G., Silver, F. L., & Gignac, M. A. M. (2015). Stroke family caregivers' support needs change across the care continuum: A qualitative study using the timing it right framework. *Disability and Rehabilitation*, 37(4), 315–324. <https://doi.org/10.3109/09638288.2014.931513>

- Carney, N., Totten, A. M., O'Reilly, C., Ullman, J. S., Hawryluk, G. W. J., Bell, M. J., Bratton, S. L., Chesnut, R., Harris, O. A., Kissoon, N., Rubiano, A. M., Shutter, L., Tasker, R. C., Vavilala, M. S., Wilberger, J., Wright, D. W., & Ghajar, J. (2017). Guidelines for the management of severe traumatic brain injury, fourth edition. *Neurosurgery*, 80(1), 6–15. <https://doi.org/10.1227/NEU.00000000000001432>
- Cicerone, K. D., Goldin, Y., Marwitz, J. H., Osier, N. D., Keatley, E., Hadley, M., Tsaousides, T., Hammond, F. M., Cantor, J., & Ashman, T. A. (2019). Evidence-based cognitive rehabilitation: Systematic review of publications from 2009 to 2014. *Archives of Physical Medicine and Rehabilitation*, 100(11), 1957–1965. <https://doi.org/10.1016/j.apmr.2019.01.018>
- Corrigan, J. D., Whiteneck, G. G., Mellick, D. C., Bushnik, T., Bell, J. M., Dams-O'Connor, K., Kolakowsky-Hayner, S. A., & Silverberg, N. D. (2021). The National Institute on Disability, Independent Living, and Rehabilitation Research Traumatic Brain Injury Model Systems program: Forty years of advancing the science and practice of TBI rehabilitation. *Journal of Head Trauma Rehabilitation*, 36(2), 77–86. <https://doi.org/10.1097/HTR.0000000000000662>
- Cramer, S. C., Dodakian, L., Le, V., See, J., Augsburger, R., McKenzie, A., Reinkensmeyer, D. J., & Schweighofer, N. (2022). Telehealth-based neurorehabilitation: A systematic review and meta-analysis. *Stroke*, 53(4), 1226–1236. <https://doi.org/10.1161/STROKEAHA.121.036980>
- Dewan, M. C., Rattani, A., Gupta, S., Baticulon, R. E., Hung, Y. C., Punchak, M., Agrawal, A., Adeleye, A. O., Shrivastava, M. G., Abdullahi, A. M., Park, K. B., & Warf, B. C. (2019). Estimating the global incidence of traumatic brain injury. *Journal of Neurosurgery*, 130(4), 1080–1097. <https://doi.org/10.3171/2017.10.JNS17352>
- Fann, J. R., Burington, A. L., Leonetti, A., Jaffe, D., Katon, W. J., & Thompson, R. S. (2004). Psychiatric illness following traumatic brain injury in an adult health maintenance organization population. *Archives of General Psychiatry*, 61(1), 53–61. <https://doi.org/10.1001/archpsyc.61.1.53>
- Feigin, V. L., Stark, B. A., Johnson, C. O., Roth, G. A., Bisignano, C., Abady, G. G., Abbasifard, M., Abbasi-Kangevari, M., Abd-Allah, F., Abedi, V., Abidi, H., & Murray, C. J. L. (2021). Global, regional, and national burden of stroke and its risk factors, 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019. *The Lancet Neurology*, 20(10), 795–820. [https://doi.org/10.1016/S1474-4422\(21\)00252-0](https://doi.org/10.1016/S1474-4422(21)00252-0)
- Gupta, S., Varghese, J., Joshy, G., & Thomas, M. (2021). Rehabilitation policy in low- and middle-income countries: A systematic review. *The Lancet Global Health*, 9(7), e1023–e1035. [https://doi.org/10.1016/S2214-109X\(21\)00149-1](https://doi.org/10.1016/S2214-109X(21)00149-1)
- Hackett, M. L., Köhler, S., O'Brien, J. T., & Mead, G. E. (2014). Neuropsychiatric aspects of stroke. *The Lancet Neurology*, 13(1), 86–95. [https://doi.org/10.1016/S1474-4422\(13\)70248-0](https://doi.org/10.1016/S1474-4422(13)70248-0)

- Heidenreich, P. A., Albert, N. M., Allen, L. A., Bluemke, D. A., Butler, J., Fonarow, G. C., Ikeda, J. S., & American Heart Association. (2022). Forecasting the future of cardiovascular disease in the United States: A policy statement from the American Heart Association. *Circulation*, 127(8), 848–876. <https://doi.org/10.1161/CIR.0b013e3182699ccf>
- Hyder, A. A., Wunderlich, C. A., Puvanachandra, P., Gururaj, G., & Kobusingye, O. C. (2007). The impact of traumatic brain injuries: A global perspective. *NeuroRehabilitation*, 22(5), 341–353. <https://doi.org/10.3233/NRE-2007-22502>
- Interagency Guidelines for Stroke Management. (2022). *Stroke rehabilitation: Clinical guidelines for post-stroke rehabilitation*. Australian Stroke Coalition.
- Judd, F., Dewey, H. M., Karmel, R., & Liu, D. (2019). Racial and ethnic disparities in access to and quality of rehabilitation services after stroke: A systematic review. *Stroke*, 50(9), 2514–2523. <https://doi.org/10.1161/STROKEAHA.119.025835>
- Kairy, D., Lehoux, P., Vincent, C., & Visintin, E. (2009). Telehealth in clinical rehabilitation: A review of the literature. *International Journal of Rehabilitation Research*, 32(1), 1–12. <https://doi.org/10.1097/MRR.0b013e32831c3597>
- Kamenov, K., Mills, A., & Chatterji, S. (2018). Global health and rehabilitation: A call for action. *The Lancet Global Health*, 6(8), e846–e847. [https://doi.org/10.1016/S2214-109X\(18\)30276-4](https://doi.org/10.1016/S2214-109X(18)30276-4)
- Langhorne, P., Bernhardt, J., & Kwakkel, G. (2011). Stroke rehabilitation. *The Lancet*, 377(9778), 1693–1702. [https://doi.org/10.1016/S0140-6736\(11\)60325-5](https://doi.org/10.1016/S0140-6736(11)60325-5)
- Laver, K. E., Lange, B., George, S., Deutsch, J. E., Saposnik, G., & Crotty, M. (2017). Virtual reality for stroke rehabilitation. *Cochrane Database of Systematic Reviews*, 11(11), CD008349. <https://doi.org/10.1002/14651858.CD008349.pub4>
- Laver, K. E., Russell, S., Chevalier, M. E., & Crotty, M. (2020). Telehealth for stroke rehabilitation during the SARS-CoV-2 pandemic: A rapid review of feasibility, efficacy, and implementation strategies. *Neurorehabilitation and Neural Repair*, 34(12), 1065–1078. <https://doi.org/10.1177/1545968320965283>
- Lisabeth, L. D., Reeves, M. J., Baek, J., & Morgenstern, L. B. (2015). Factors influencing sex differences in post-stroke functional outcome. *Stroke*, 46(3), 860–863. <https://doi.org/10.1161/STROKEAHA.114.007714>
- Luengo-Fernandez, R., Violato, M., Candela, P., & Leal, J. (2020). Economic burden of stroke across Europe: A population-based cost analysis. *European Stroke Journal*, 5(1), 17–25. <https://doi.org/10.1177/2396987319880316>
- Maas, A. I. R., Menon, D. K., Manley, G. T., Abrams, M., Åkerlund, C., Andelic, N., Aries, M., Bashford, T., Bell, M. J., Bender, S. J., & Yaffe, K. (2022). Traumatic brain injury: Progress and challenges for prevention, clinical care, and research. *The Lancet Neurology*, 21(11), 1004–1060. [https://doi.org/10.1016/S1473-4422\(22\)00309-4](https://doi.org/10.1016/S1473-4422(22)00309-4)
- Mant, J., Carter, J., Wade, D., & Winner, S. (2017). Family support for stroke: A randomised controlled trial. *The Lancet*, 356(9232), 808–813. [https://doi.org/10.1016/S0140-6736\(00\)02662-0](https://doi.org/10.1016/S0140-6736(00)02662-0)

- Mehrholz, J., Thomas, S., Werner, C., Kugler, J., Pohl, M., & Elsner, B. (2018). Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. *Cochrane Database of Systematic Reviews*, 5(5), CD006876. <https://doi.org/10.1002/14651858.CD006876.pub5>
- National Institute for Health and Care Excellence. (2023). *Stroke rehabilitation in adults* (NICE Guideline No. NG236). NICE.
- Nijland, R., van Wegen, E., Harmeling-van der Wel, B. C., & Kwakkel, G. (2010). Presence of finger extension and shoulder abduction within 72 hours after stroke predicts functional recovery: Early prediction of functional outcome after stroke. *Stroke*, 41(4), 745–750. <https://doi.org/10.1161/STROKEAHA.109.572065>
- Pollock, A., Farmer, S. E., Brady, M. C., Langhorne, P., Mead, G. E., Mehrholz, J., & van Vliet, P. (2014). Interventions for improving upper limb function after stroke. *Cochrane Database of Systematic Reviews*, 11(11), CD010820. <https://doi.org/10.1002/14651858.CD010820.pub2>
- Royal College of Physicians. (2023). *National clinical guideline for stroke for the United Kingdom and Ireland* (6th ed.). Royal College of Physicians.
- Schwamm, L. H., Holloway, R. G., Amarenco, P., Aude, Y. W., Biller, J., Gress, D., Johnston, K. C., & Summers, D. (2009). A review of the evidence for the use of telemedicine within stroke systems of care: A scientific statement from the American Heart Association/American Stroke Association. *Stroke*, 40(7), 2616–2634. <https://doi.org/10.1161/STROKEAHA.109.192360>
- Turner-Stokes, L., Sykes, C., Silber, E., Khatri, A., & Young, T. (2015). An evidence-based review of the effectiveness of multidisciplinary neurorehabilitation for people with non-progressive conditions. *Clinical Rehabilitation*, 22(11), 961–976. <https://doi.org/10.1177/0269215508090676>
- United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development*. United Nations.
- Winward, C. E., Sackley, C. M., Barker, K. L., & Wade, D. T. (2002). A physiotherapy regime of assessment and treatment for arm function after stroke: A pilot randomised trial. *Clinical Rehabilitation*, 16(6), 607–617. <https://doi.org/10.1191/0269215502cr539oa>
- World Health Organization. (2011). *World report on disability*. WHO.
- World Health Organization. (2019). *Rehabilitation in health systems: Guide for action*. WHO.
- World Health Organization. (2023). *Global report on health equity for persons with disabilities*. WHO.