“How good are we at predicting stroke outcomes?”

Dr Timothy Lapp MD FRCPC (PMR)

MAHC- Huntsville Grand Rounds February 4, 2026

Disclosures

- Zip

Objectives

- 1. List clinical measures and investigations used in predicting stroke outcomes
- 2. Identify which measures are most useful
- 3. Consider future methods of predicting stroke outcomes

Why and when are we asked to predict?

- Hyperacute setting - prognosis, treatment decisions
- Admission to hospital - expectations for patient/family
- Team meetings - Nursing, therapists
- Rehab admission - intensity of care
- Discharge - destination, resource allocation, goal setting

What methods do *you* use?

- Recent experiences?
- Similar case?
- PMHx?
- Clinical findings?
- Functional scales?
- Imaging?
- Hybrid?

Expertise

- Experts in stroke care are correct only 17% of the time in predicting death or disability at discharge (Saposnik et al, 2013))
- Experts wrong more than half the time in all predictions post stroke, and worse post thrombolysis (Ntaois et al, 2016)
- PT’s asked to predict only upper limb motor function within 3 days of admission had R2 of only 0.62 (moderate variability) (Rinske H et al, 2013)
- Why? - cognitive biases, heterogeneous disease, variable co-morbidities, unaware of pre-stroke functioning, variable genetics, inconsistent health care settings, widely different social supports

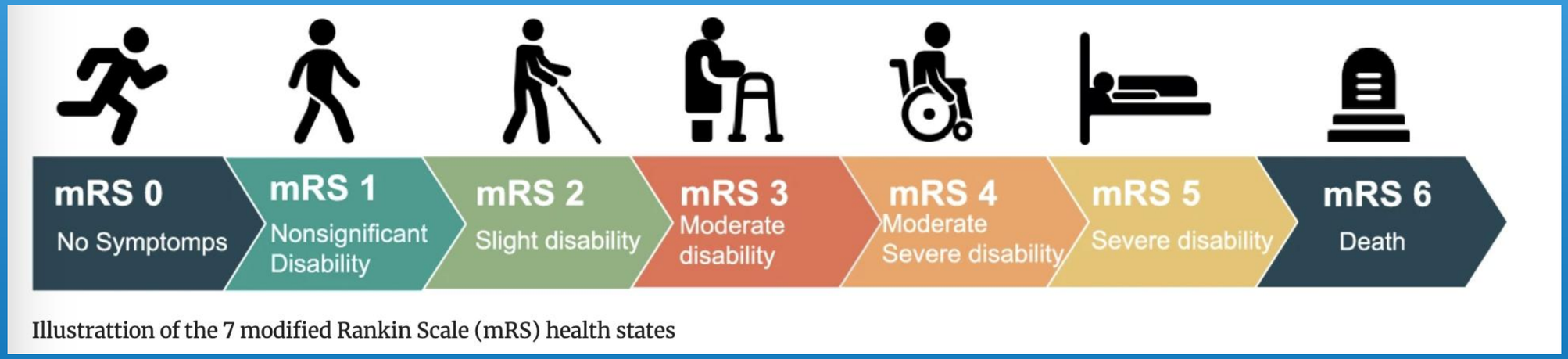
Functional scales

(Which ones are best?)

- NIHSS
- mRS
- AlphaFIM
- Full FIM
- Barthel Index
- Glascow Outcome
- CNS
- ASTRAL, DRAGON, SEDAN, PLAN, iSCORE, HIAT, THRIVE, SPAN…

Modified Rankin Scale (mRS)

- Used often in stroke research to *classify* patients
- 0-2 = minimally disabled
- 3-6 = moderate/severe
- 6 = death



Illustrattion of the 7 modified Rankin Scale (mRS) health states

Scale inclusions

What to include and where to stop?

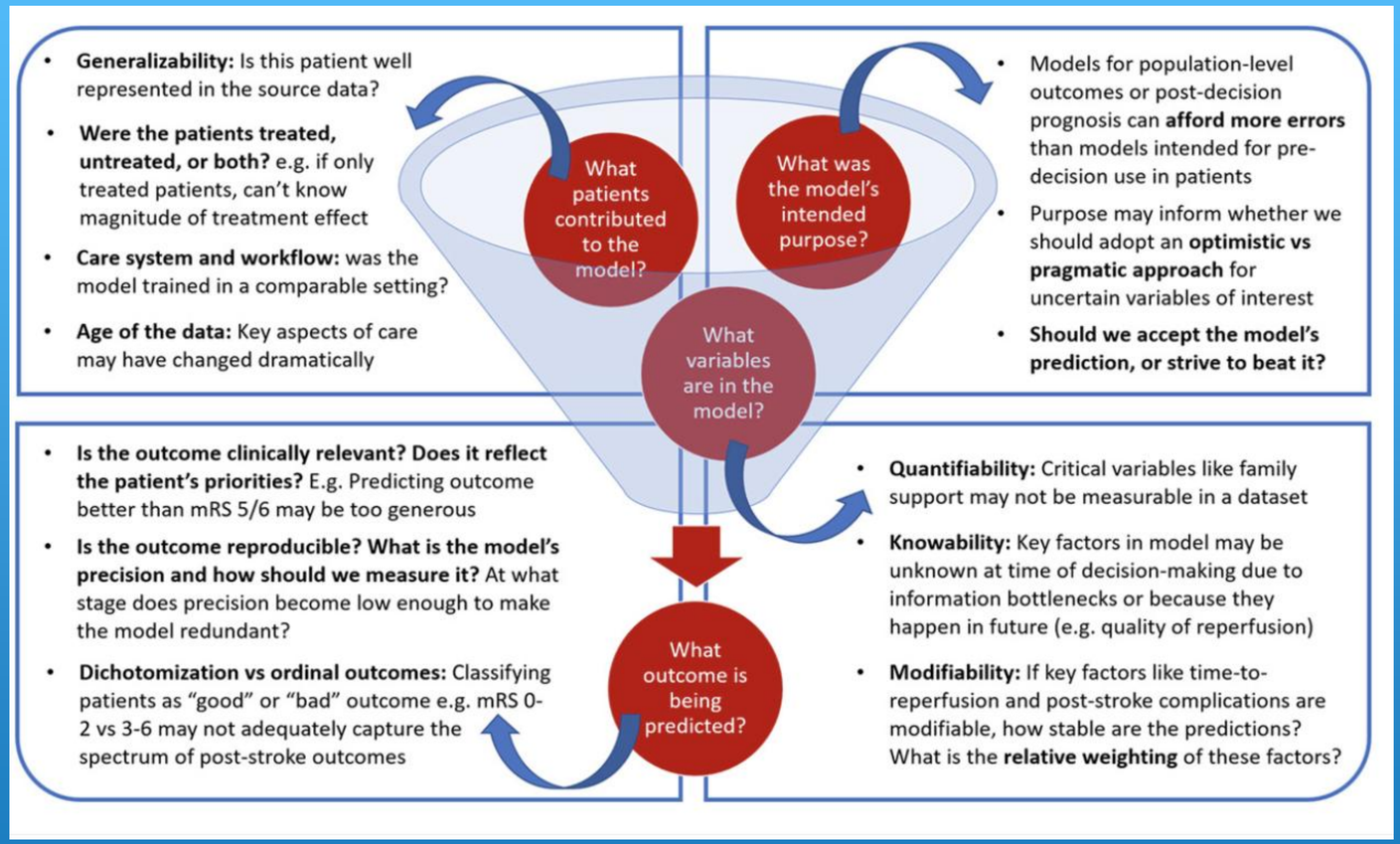
- Age/sex
- LOC
- Time from stroke, and various logistical measures up to thrombolysis (door to needle etc)
- Acute stroke scores (NIHSS, CNS)
- Limb weakness/visual deficits
- Risk factors (HPT, A Fib, Hyperlipidemia, DM, smoking, previous CVA/MI/PVD)
- Cancer
- CHF
- Renal Dialysis
- Pre-stroke functioning

Scales’ predictive success?

- NIHSS (National Institute of Health Stroke Scale) - 0 (no deficit) to 42 (severe deficit) Accurately predicts severe disability/death (>=16) or excellent outcomes (<=6) (Adams et al 1999)
- mRS - Day 4 and day 90 scores highly correlated for mRS 0-2, and 6 (Asanad 2017)
- AlphaFIM - 4 motor items and 2 cognitive items. Acute scores could predict full FIM scores at admission to and discharge from Rehab units. Could not predict community discharge (Stillman et al 2009)
- FIM - predicts admission to rehab facility vs skilled nursing facility, institutionalized care vs home (Thorpe et al 2018)
- REMEMBER - Predictive models are used for large groups not *your* patient

Predictive Models - combining clinical data and scales

Goyal, 2021, "Challenges of outcome prediction for acute stroke treatment decisions"



- Conclusion - All models run into a "prediction ceiling" and are not "clinically useable"

Predictive Models Success?

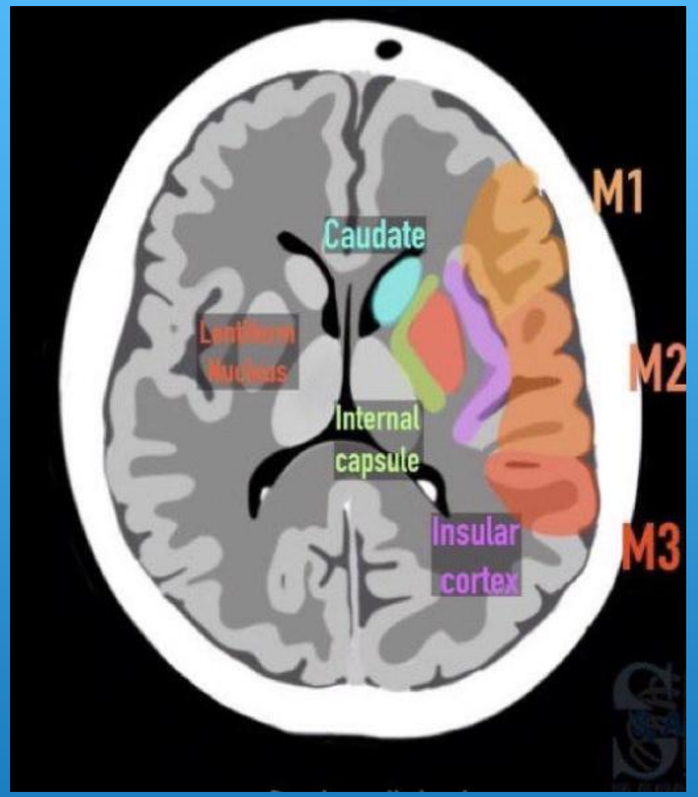
Matsumoto et al, 2020, “Stroke prognostic scores and data driven prediction of clinical outcomes after acute ischemic stroke”

- 6 prognostic scores evaluated for data driven machine learning models
- Similarly good at predicting death (mRS=6)
- Marginally better than best clinical prognostic scores
- Still dichotomized predictions (mRS 0-2 or 3-6)
- No nuanced predictions
- Limitations - race/ethnicity/background, health care system, hospital type, evolving hyperacute care
- “…can’t be the sole foundation for decision making. Experienced comprehensive assessment and clinical acumen must still play a role.”

What about imaging?

Does ASPECTS help? (Alberta Stroke Program Early CT Score)

- Designed in Calgary 2000
- Initially used non-contrast CT to estimate volume of MCA infarctions to predict outcomes, intracranial hemorrhage post thrombolysis, and eligibility for EVT (since used with CT perfusion and DWI MRI with similar results)
- Scale of 0 (extensive ischemia) - 10 (normal)
- <7 = increased risk of functional dependence (mRS >2)
- >=6 = EVT eligible
- Still only binary predictions



Current Limitations to accurate predictions

- Heterogeneous disease (infarct vs hemorrhage, MCA/ACA/Basilar/PCA)
- Heterogeneous impairments (paresis, ataxia, speech, visual, perceptual, etc)
- Influence of numerous comorbidities
- Evolving stroke care - hyperacute, rehabilitation
- Evolving imaging technology
- Models are not dynamic. They don’t provide trajectory of recovery predictions
- No agreement on “functional outcome measures” nor “end date“ of measurements (30d-12mo?)
- Non-standardized care (within MAHC, province, country)
- Variable family/community /financial support

What should we do?

- Combine all available data - clinical assessment
  imaging
  scales
- Communicate uncertainty
- Plan early for rehabilitation
- Reassess patient regularly

How soon will we be better at predicting stroke outcomes?

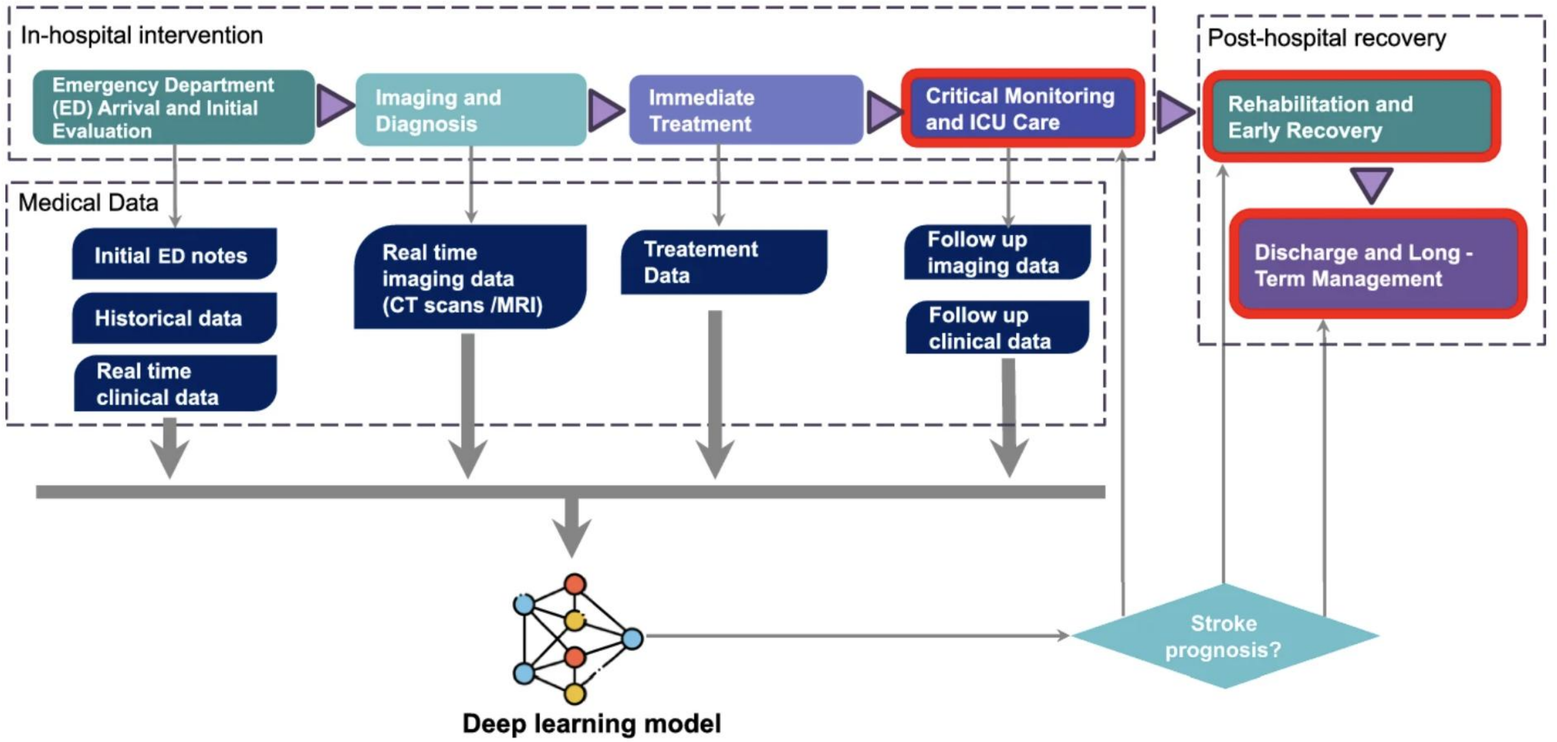
Stay Tuned…AI?

Barouhou et al, 2025 “Unlocking the potential of deep learning in brain stroke prognosis: a systematic review”

- 38 studies reviewed between 2017-2022
- “Machine Learning” - limited by human input to guide the algorithm
- “Deep Learning” - uses artificial neural networks (ANN) to determine appropriate weights and biases of input data to generate a prediction

Artificial Intelligence - Deep Learning

From: Unlocking the potential of deep learning in brain stroke prognosis: a systematic literature review



Key steps for a stroke prognosis DL based decision support system

Stay Tuned…Genomics?

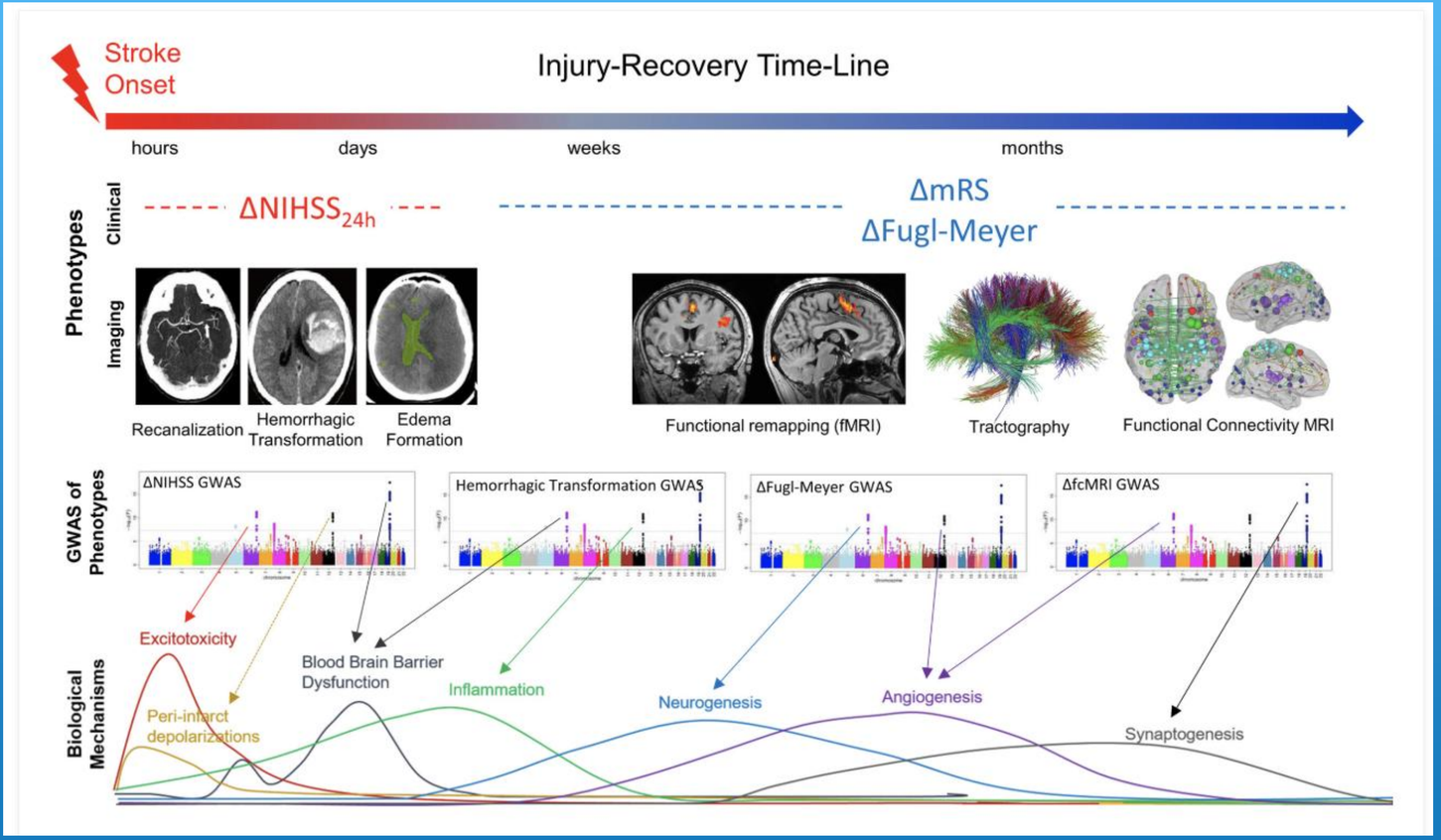
Soderholm M, “Genome-wide association meta-analysis of functional outcome and ischemic stroke”, 2019

- Single significant variant identified associated with outcome 3 mo post-stroke
- “plausible mechanistic links to post-stroke recovery” related to a protein known to be involved with neuroplasticity, among other brain functions

Genomics

Lee JM, Using human genetics to understand mechanisms in ischemic stroke outcome: From early brain injury to long-term recovery, 2021

- >30 Genome Wide Association Studies (GWAS) looking for stroke risk factors
- Only a few looking for stroke outcome factors
- Need for larger studies, that also look at other other techniques beyond GWAS



Done

References

- Barouhou A, Unlocking the potential of deep brain learning in brain stroke prognosis: a systematic review. Artif Intel Rev 58, 375(2025)
- MAO MMY et al, The art and science of stroke outcome prognostication. Editorial, Stroke J Editorial, March 2020, Volume 51, No 5
- Ntaios G et al, ASTRAL, DRAGON, and SEDAN scores predict stroke outcome more accurately than physicians. Our J Neurol 2016, 23:1651-1657
- Matsumoto et al, Stroke prognostic scores an data-driven prediction of clinical outcomes after acute ischemic stroke. Stroke 2020;51:1477-1483
- Goyal M, Challenges of outcome prediction for acute stroke treatment decisions. Stroke, March 2021, Vol 52, No 5

More References

- Saposonik G et al, JURaSSiC: accuracy clinician vs risk score prediction of ischemic stroke outcomes, Neurology. 2013 Jul 30; 81(5):448-55
- Garcia-Rudolph A et al, Predicting length of stay in patients admitted to stroke rehabilitation with severe and moderate levels of functional impairments, Medicine 2020 Oct 23, 99(43):p e22423
- Van der Groen O et al, Point of view on outcome prediction models in post-stroke motor recovery. Neurorahol Neural Repair 2024 May:38(5):386-98
- Rinske H et al, Accuracy of physical therapists' early predictions of upper-limb function in hospital stroke units:The EPOS study. Physical Therapy 2013 April 1 Vol 93, Issue 4:460-469
- Coupar F et al, Predictors of upper limb recovery after stroke: a systematic review and meta-analysis. Clinical Rehabilitation 2011Oct 24, Vol 26, Issue 4

More and More References

- Soderholm M et al, Genome-wide association meta-analysis of functional outcome after ischemic stroke, Neurology 2019 March 19, 92(12)e1271-e1283
- Bonkhoff A and Greeks C, Precision medicine in stroke: towards personalized outcome predictions using artificial intelligence, Brain Feb 2022, Vol 145, Issue 2:457-475
- Schroder J and Thomalla G, A critical review of Alberta Stroke Program Early CT Score for evaluation of acute stroke imaging, Front Neurology. 2017 Jan 12:7:245
- Adams H et al, Baseline NIH Stroke Stroke Score strongly predicts outcome after stroke: a report of the trial of org 10172 in acute stroke treatment (TOAST). Neurology 1999, 53(1):126
- Asanad S et al, Modified Rankin Scale disability status at day 4 poststroke is an informative predictor of final day outcome. Neurology 2017 April 18, 88(16 supplement):P6.271
- Stillman M et al, Projecting function of stroke patients in rehabilitation using the AlphaFIM instrument in acute care, PM&R 2009 March Vol 1(Issue 3):234-239
- Thorpe E et al, Outcome measure scores predict discharge destination in patients with acute and subacute stroke: A systematic review and series of meta-analyses. J of Neurologic Phys Therapy 2018 January, 42(1):2-11