

## Supplementary Online Content

Rebchuk AD, O'Neill ZR, Szefer EK, Hill MD, Field TS. Health utility weighting of the modified Rankin Scale: a systematic review and meta-analysis. *JAMA Netw Open*. 2020;3(4):e203767. doi:10.1001/jamanetworkopen.2020.3767

**eMethods.** Supplemental Methods

**eTable 1.** Aggregate Demographic Data of Included Studies

**eTable 2.** Mean Utility Weights by mRS Level (UW-mRS), With Associated 95% CIs and Number of Included Patients for Each Health Utility Scale

**eTable 3.** Mean Stroke Impact Scale (SIS) Utility Weights by mRS Level, With Associated 95% CIs, Number of Patients, and Number of Studies Contributing Data, for Each SIS Domain

**eTable 4.** Risk of Bias Results for Included Articles

This supplementary material has been provided by the authors to give readers additional information about their work.

## eMethods. Supplemental Methods

### Medline Search Strategy

1	exp STROKE/
2	Cerebrovascular Disorders/
3	Carotid Artery Thrombosis/
4	Brain Ischemia/
5	Cerebral Infarction/
6	Ischemic Attack, Transient/
7	Vertebral Artery Dissection/
8	Cervical Artery Dissection.mp.
9	Intracranial Artery Dissection.mp.
10	Cerebral Hemorrhage/
11	Subarachnoid Hemorrhage/
12	stroke\$.mp.
13	cerebral vasc\$.mp.
14	cerebrovasc\$.mp.
15	cva.mp.
16	transient isch?emic attack\$.mp.
17	tia\$.mp.
18	or/1-17
19	"Quality of Life"/
20	Health Status/
21	Health Status Indicators/
22	quality of health.mp.
23	QoL.mp.
24	SS-QoL.mp.
25	Stroke Impact Scale.ti,ab.
26	Stroke Adapted Sickness Impact Profile.ti,ab.
27	Stroke-Specific Quality of Life Measure.ti,ab.
28	health related quality of life.mp.
29	HRQoL.mp.
30	HRQL.mp.

31	health utility.mp.
32	"Outcome Assessment (Health Care)"/
33	quality adjusted life year\$.mp.
34	Quality-Adjusted Life Years/
35	QALY\$.mp.
36	utility weight\$.mp.
37	utility?weight\$.mp.
38	disability weight\$.mp.
39	Disability Evaluation/
40	DALY\$.mp.
41	EuroQoL.mp.
42	Euro-QoL.mp.
43	Neuro?QoL.mp.
44	EQ-5D-3L.mp.
45	EQ-5D-5L.mp.
46	EQ-5D.mp.
47	SF-36.mp.
48	Standard Gamble.mp.
49	SG.mp.
50	Time trade?off*.mp.
51	TTO.mp.
52	Person trade?off*.mp.
53	PTO.mp.
54	Visual Analogue Scale.mp.
55	VAS.mp.
56	or/19-55
57	mRS\$.mp.
58	modified rankin scale.mp.
59	57 or 58
60	18 and 56 and 59

#### Embase Search Strategy

1	exp *cerebrovascular accident/
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2	cva.ti,ab.
3	stroke\$.ti,ab.
4	exp *brain ischemia/
5	*brain infarction/
6	cerebral infarction.ti,ab.
7	exp *cerebrovascular disease/
8	*transient ischemic attack/
9	tia.ti,ab.
10	transient isch?emic attack\$.ti,ab.
11	*Cerebral Hemorrhage/
12	*Subarachnoid hemorrhage/
13	Vertebral Artery Dissection.ti,ab.
14	Cervical Artery Dissection.ti,ab.
15	Intracranial Artery Dissection.ti,ab.
16	(cerebro?vasc: disease* or cerebral vasc: disease*).ti,ab.
17	or/1-14
18	exp "quality of life"/
19	exp health status/
20	exp health status indicator/
21	quality of health.mp.
22	QoL.mp.
23	health related quality of life.mp.
24	SS-QoL.mp.
25	Stroke Adapted Sickness Impact Profile.ti,ab.
26	Stroke Impact Scale.ti,ab.
27	Stroke-Specific Quality of Life Measure.ti,ab.
28	HRQoL.mp.
29	HRQL.mp.
30	health utility.mp.
31	quality adjusted life year/
32	Quality?Adjusted Life Year\$.mp.
33	QALY\$.mp.

34	utility weight\$.mp.
35	utility?weight\$.mp.
36	outcome assessment/
37	disability weight\$.mp.
38	DALY.mp.
39	disability evaluation.mp.
40	Euro?QoL.mp.
41	Neuro?QoL.mp.
42	EQ-5D-3L.mp.
43	EQ-5D-5L.mp.
44	EQ-5D.mp.
45	SF-36.mp.
46	Standard Gamble.mp.
47	SG.mp.
48	TTO.mp.
49	Time trade-off.mp.
50	Time trade?off\$.mp.
51	Person trade-off.mp.
52	Person trade?off\$.mp.
53	PTO.mp.
54	Visual Analogue Scale.mp.
55	VAS.mp.
56	or/18-55
57	rankin scale/
58	modified rankin scale.mp.
59	mRS.mp.
60	or/57-59
61	17 and 56 and 60

#### **PsycINFO Search Strategy**

1	DE "Cerebrovascular Accidents"
2	DE "Cerebrovascular Disorders"
3	DE "Cerebral Ischemia"
4	DE "Cerebral Hemorrhage"

5	stroke
6	cva
7	DE "Quality of Life"
8	DE "Health Care Costs"
9	DE "Health Care Economics"
10	DE "Occupational Status"
11	DE "Treatment Outcomes"
12	DE "Physical Health Assessment"
13	DE "Rating Scales"
14	DE "Surveys"
15	DE "Evaluation"
16	DE "Utility Theory"
17	QoL
18	health status
19	Health status indicators
20	quality of health
21	health related quality of life
22	HRQoL
23	HRQL
24	health utility
25	quality adjusted life years
26	QALY
27	utility weight
28	disability weight
29	EuroQoL
30	euro-QoL
31	neuro-QoL
32	EQ-5D
33	EQ-5D-3L
34	EQ-5D-5L
35	SF-36
36	time trade off
37	TTO

38	person trade off
39	person tradeoff
40	PTO
41	visual analogue scale
42	VAS
43	modified rankin scale
44	mRS
45	rankin scale
46	43 OR 44 OR 45
47	Vertebral Artery Dissection
48	Cervical Artery Dissection
49	Intracranial Artery Dissection
50	Cerebral Hemorrhage
51	Subarachnoid Hemorrhage
52	cerebrovascular accident
53	cerebrovascular disorders
54	transient ischemic attack
55	1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 47 OR 48 OR 49 OR 50 OR 51 OR 52 OR 53 OR 54
56	s-qol
57	Stroke Impact Scale
58	Stroke Adapted Sickness Impact Profile
59	Stroke-Specific Quality of Life Measure
60	7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 or 56 or 57 or 58 or 59
61	46 AND 55 AND 60

## **Risk of Bias Tool**

### **Explanation**

Because no standardized tool exists to assess the risk of bias in observational studies (Sanderson et al., 2007) we modified risk of bias tools used in recently published meta-analysis of imaging markers for stroke risk (Gupta et al., 2016; Gupta et al., 2013; Gupta et al. 2015). We generated 10 questions to assess potential selection, detection, reporting, attrition and confounding bias in included studies.

## **Type of bias**

### **Selection**

- Were the inclusion and exclusion criteria clearly described?
- Was the sample randomly selected or community-dwelling (to reduce selection bias)?
- Were the rationale for removing outlier data reported?

### **Detection**

- Were mRS assessors blinded to the treatment/intervention/experimental status of the patient?

### **Reporting**

- Did more than one investigator assess mRS outcomes?
- Structured mRS questionnaire?

### **Attrition**

- Were losses to follow-up recorded and reported?

### **Confounding**

- Were comorbidities reported?
- Was the time post-stroke of data collection reported?
- Were rates of proxy completion given by mRS level?

## **Data Collection Form**

- Article
  - Title:
  - Author(s):
  - Year:
  - Journal:
  - Link:
- Basic Data
  - Study Type (incl. prospective/retrospective; Randomized vs prospective vs observational):
  - Center (Single center v multi center):
  - Center (Single center v multi center):
  - n:
  - Sex (%female):
  - Mean age (SD):
  - Countries of Pts:
  - Comorbidities (vascular RF, preexisting QoL, prev stroke):
  - Comorbidities (HTN, DM, CKD, Afib, CAD, hyperlipidemia, smoking Hx):
  - Race/Ethnicity:
  - Religion:
  - Employment Status:
  - % proxy completed:
  - QoL scale:
  - Method of Health Utility:
  - TTO or PTO:



- Who collected HU (e.g. nurse, physician):
- Stroke Data
  - Stroke Type:
  - Time since event:
  - Barthel Index [mean (SD)]:
  - NIHSS:
  - Intervention/Tx:
  - Stroke Def'n (copy):
- Mapping (w/ SDs, CIs)
  - mRS 0:
  - mRS 1:
  - mRS 2:
  - mRS 3:
  - mRS 4:
  - mRS 5:

**eTable 1.** Aggregate Demographic Data of Included Studies. Mean and standard deviations weighted by sample size of studies reporting data

Demographic Variable	Mean (SD)	Studies reporting data (n)
<b>Previous stroke or TIA</b>	21% (4%)	7
<b>Co-Morbidities</b>		
Hypertension	67% (8%)	11
Diabetes	21% (2%)	7
Atrial fibrillation	16% (11%)	8
Hyperlipidemia	22% (14%)	5
Coronary artery disease	20% (4%)	5
Heart Failure	5% (4%)	4
Myocardial infarction	7% (6%)	2
Smoking	43% (7%)	4
Alcohol use	31%	1
<b>Race/Ethnicity</b>		
Caucasian	77% (7%)	8
Black	19% (4%)	6
Asian	95% (18%)	2
Mixed	41.4%	1
Indigenous	1.2%	1
<b>Employment</b>		
Retired	61% (8%)	3
Full-time	22% (4%)	4
Part-time	8% (3%)	2
Unemployed	10% (1%)	2
Housework	17%	1

**eTable 2.** Mean Utility Weights by mRS Level (UW-mRS), With Associated 95% CIs and Number of Included Patients for Each Health Utility Scale. Pairwise testing performed with Tukey's post-hoc, significance levels are denoted by \* ( $p < 0.05$ ), † ( $p < 0.01$ ) and ‡ ( $p < 0.001$ )

Health Utility Metric	Studies: analyzed / identified	Total Patients (n)	mRS 0	mRS 1	mRS 2	mRS 3	mRS 4	mRS 5	p value
EQ-5D	9/12	9607	0.93 (0.96, 0.90) [n = 3624]	0.86 (0.89, 0.83) [n = 2376]	0.68 (0.72, 0.64) [n = 1149]	0.57 (0.61, 0.53) [n = 957]	0.31 (0.35, 0.26) [n = 1101]	0.06 (0.12, 0.00) [n = 400]	<.0001
			All pairwise significant†.						
SF-36-PF	1/2	278	0.68 (0.81, 0.55) [n = 10]	0.61 (0.67, 0.55) [n = 61]	0.43 (0.48, 0.39) [n = 88]	0.31 (0.37, 0.25) [n = 65]	0.12 (0.17, 0.07) [n = 52]	0 (0, 0) [n = 2]	<.0001
			All pairwise significant‡, except mRS 0-1, 1-2, 2-3, 3-4 and 4-5.						
SF-36-SF	1/1	278	0.84 (1.0, 0.68) [n = 10]	0.81 (0.87, 0.76) [n = 61]	0.66 (0.71, 0.61) [n = 88]	0.57 (0.63, 0.51) [n = 65]	0.55 (0.64, 0.47) [n = 52]	0.25 (0.25, 0.25) [n = 2]	<.0001
			All pairwise significant‡, except mRS 0-1, 1-2, 2-3, 2-4, and 3-4.						
WHO-GBDP	1/1	54	1.0 (1.0, 1.0) [n = 9]	0.95 (1.0, 0.91) [n = 9]	0.79 (0.83, 0.75) [n = 9]	0.67 (0.71, 0.63) [n = 9]	0.35 (0.37, 0.32) [n = 9]	0.06 (0.13, -0.01) [n = 9]	<.0001
			All pairwise significant*, except mRS 0-1.						
PROMIS-PF	1/1	236	0.53 (0.55, 0.51) [n = 50]	0.46 (0.48, 0.44) [n = 50]	0.40 (0.42, 0.38) [n = 35]	0.34 (0.36, 0.32) [n = 41]	0.26 (0.29, 0.23) [n = 39]	0.18 (0.20, 0.16) [n = 21]	<.0001
			All pairwise significant†.						

<b>Neuro-QoL</b>	1/1	236	0.58 (0.59, 0.56) [n = 50]	0.52 (0.54, 0.50) [n = 50]	0.47 (0.50, 0.45) [n = 35]	0.39 (0.41, 0.37) [n = 41]	0.27 (0.30, 0.24) [n = 39]	0.17 (0.18, 0.15) [n = 21]	<.0001
			All pairwise significant‡, except mRS 0-1 and 1-2.						
<b>HRQOLISP</b>	1/1	103	0.66 (0.75, 0.57) [n = 4]	- (-, -) [n = 0]	0.66 (0.69, 0.63) [n = 38]	0.63 (0.65, 0.61) [n = 25]	0.62 (0.67, 0.56) [n = 8]	0.58 (0.62, 0.55) [n = 28]	0.0078
			No significant pairwise differences.						
<b>AQoL-4D</b>	1/1	1523	0.80 (0.83, 0.77) [n = 186]	0.78 (0.80, 0.76) [n = 404]	0.63 (0.65, 0.61) [n = 415]	0.37 (0.39, 0.35) [n = 456]	0.11 (0.12, 0.10) [n = 267]	0.03 (0.04, 0.02) [n = 195]	<.0001
			All pairwise significant‡, except mRS 0-1.						
<b>SIS (incl. components)</b>	5/5	422-777	See eTable3.						

**eTable 3.** Mean Stroke Impact Scale (SIS) Utility Weights by mRS Level, With Associated 95% CIs, Number of Patients, and Number of Studies Contributing Data, for Each SIS Domain. Studies legend: Katzan 2017 (p), Carod-Artal 2008 (‡), Vellone 2013 (\*), Carod-Artal 2009 (f) and Duncan 1999 (†).

SIS Subscale	Total Patients (n)	mRS 0	mRS 1	mRS 2	mRS 3	mRS 4	mRS 5	p value
<b>Strength</b> (†§#)	422	- (-, -) [n = 0, studies = 0]	0.76 (0.62, 0.89) [n = 70, studies = 3]	0.52 (0.40, 0.63) [n = 108, studies = 3]	0.39 (0.29, 0.49) [n = 102, studies = 3]	0.31 (0.24, 0.39) [n = 142, studies = 3]	- (-, -) [n = 0, studies = 0]	<.0001
<b>Hand Function</b> (†§#)	422	- (-, -) [n = 0, studies = 0]	0.66 (0.47, 0.86) [n = 70, studies = 3]	0.31 (0.21, 0.42) [n = 108, studies = 3]	0.11 (0.06, 0.17) [n = 102, studies = 3]	0.08 (0.05, 0.11) [n = 142, studies = 3]	- (-, -) [n = 0, studies = 0]	<.0001
<b>Mobility</b> (†§#)	422	- (-, -) [n = 0, studies = 0]	0.78 (0.67, 0.90) [n = 70, studies = 3]	0.62 (0.52, 0.72) [n = 108, studies = 3]	0.49 (0.40, 0.58) [n = 102, studies = 3]	0.22 (0.16, 0.28) [n = 142, studies = 3]	- (-, -) [n = 0, studies = 0]	<.0001
<b>ADL/IADL</b> (†§#)	422	- (-, -) [n = 0, studies = 0]	0.81 (0.71, 0.92) [n = 70, studies = 3]	0.63 (0.54, 0.73) [n = 108, studies = 3]	0.45 (0.39, 0.52) [n = 102, studies = 3]	0.29 (0.22, 0.35) [n = 142, studies = 3]	- (-, -) [n = 0, studies = 0]	<.0001
<b>Memory/ Thinking</b> (†‡§#)	537	74.4 (0.32, 1.17) [n = 6, studies = 1]	0.76 (0.68, 0.83) [n = 111, studies = 4]	0.77 (0.72, 0.82) [n = 175, studies = 4]	0.67 (0.60, 0.74) [n = 173, studies = 4]	0.57 (0.51, 0.62) [n = 303, studies = 4]	0.38 (0.23, 0.54) [n = 39, studies = 1]	<.0001
<b>Communication</b> (†§#)	422	- (-, -) [n = 0, studies = 0]	0.83 (0.72, 0.94) [n = 70, studies = 3]	0.80 (0.72, 0.88) [n = 108, studies = 3]	0.68 (0.55, 0.81) [n = 102, studies = 3]	0.78 (0.70, 0.87) [n = 142, studies = 3]	- (-, -) [n = 0, studies = 0]	0.3431
<b>Emotion</b> (†‡§#)	777	0.76 (0.42, 1.11) [n = 6, studies = 1]	0.57 (0.51, 0.62) [n = 111, studies = 4]	0.59 (0.54, 0.64) [n = 175, studies = 4]	0.51 (0.46, 0.55) [n = 173, studies = 4]	0.52 (0.48, 0.56) [n = 303, studies = 4]	0.45 (0.32, 0.58) [n = 39, studies = 1]	0.0399

<b>Social Participation</b> (†‡§#)	777	0.59 (0.06, 1.11) [n = 6, studies = 1]	0.59 (0.52, 66) [n = 111, studies = 4]	0.53 (0.46, 0.59) [n = 175, studies = 4]	0.44 (0.38, 50.1) [n = 173, studies = 4]	0.32 (0.27, 0.36) [n = 303, studies = 4]	0.15 (0.07, 0.24) [n = 39, studies = 1]	<.0001
<b>Composite Physical</b> (†‡§#)	777	0.57 (-0.01, 1.15) [n = 6, studies = 1]	0.70 (0.62, 0.78) [n = 111, studies = 4]	0.54 (0.48, 0.60) [n = 175, studies = 4]	0.40 (0.36, 0.45) [n = 173, studies = 4]	0.22 (0.18, 0.25) [n = 303, studies = 4]	0.08 (0.01, 0.15) [n = 39, studies = 1]	<.0001
<b>Stroke Global Disability</b> (†‡)	459	0.50 (0.06, 0.94) [n = 6, studies = 1]	0.66 (0.57, 0.75) [n = 74, studies = 2]	0.57 (0.50, 0.64) [n = 113, studies = 2]	0.47 (0.41, 0.54) [n = 113, studies = 2]	0.34 (0.28, 0.39) [n = 214, studies = 2]	0.18 (0.10, 0.26) [n = 39, studies = 1]	<.0001
<b>SIS16</b> (*)	672	0.98 (0.90, 1.07) [n = 21, studies = 1]	0.92 (.90, 0.95) [n = 283, studies = 1]	0.77 (0.73, 0.80) [n = 330, studies = 1]	0.56 (0.52, 0.61) [n = 218, studies = 1]	0.27 (0.20, 0.34) [n = 101, studies = 1]	0.08 (0.02, 0.14) [n = 16, studies = 1]	<.0001

<b>eTable 4. Risk of Bias Results for Included Articles</b>												
<b>Title</b>	<b>Journal</b>	<b>Year</b>	<i>Inclusion and exclusion criteria clearly described?</i>	<i>Randomly selected sample or community-dwelling?</i>	<i>Rationale for removing outlier data reported?</i>	<i>mRS assessors blinded to the status of the patient?</i>	<i>Multiple investigator assesses mRS outcomes?</i>	<i>Structured mRS questionnaire?</i>	<i>Losses to follow-up reported?</i>	<i>Comorbidities reported?</i>	<i>Time post-stroke reported?</i>	<i>Proxy rates by mRS level?</i>
Utility-Weighted Modified Rankin Scale as Primary Outcome in Stroke Trials: A Simulation Study.	Stroke	2018	yes	Randomly selected	no	no	no	no	yes	yes	yes	no
Comparison of 3-Month Stroke Disability and Quality of Life across Modified Rankin Scale Categories.	Interventional Neurology	2017	yes	Randomly selected	no	yes	no	no	no	no	yes	no
Lifetime health effects and medical costs of integrated stroke services - a non-randomized controlled cluster-trial based life table approach.	Cost Effectiveness & Resource Allocation	2017	yes	Randomly selected	no	yes	yes	no	yes	yes	yes	no
Added Value of Patient-Reported Outcome Measures in Stroke Clinical Practice.	Journal of the American Heart Association	2017	no	Community dwelling	no	no	no	yes	yes	no	yes	no
Web-Based Assessment of Outcomes After Subarachnoid and Intracerebral Hemorrhage: A New Patient Centered Option for Outcomes Assessment.	Neurocritical Care	2015	yes	Community dwelling	no	no	no	yes	yes	yes	yes	no
Validity of EQ-5D-5L in stroke.	Quality of Life Research	2015	yes	Community dwelling	no	no	no	yes	yes	no	yes	no
Testing for differential item functioning within the EQ-5D.	Medical Decision Making	2013	yes	Randomly selected	yes	no	no	yes	no	no	yes	yes
Medical care for chronic-phase stroke in Japan.	Neurologia Medico-Chirurgica	2012	yes	Community dwelling	no	no	no	yes	yes	no	yes	no
Mapping the modified Rankin scale (mRS)	Medical Decision	2010	yes	Randomly selected	no	no	no	yes	yes	no	yes	no

measurement into the generic EuroQol (EQ-5D) health outcome.	Making											
Quantifying the value of stroke disability outcomes: WHO global burden of disease project disability weights for each level of the modified Rankin Scale.	Stroke	2009	n/a	n/a	no	no	yes	yes	n/a	no	no	n/a
The stroke impact scale 3.0: evaluation of acceptability, reliability, and validity of the Brazilian version.	Stroke	2008	yes	Randomly selected	no	no	no	no	no	yes	yes (mean varied between participants)	no
Physical and social functioning after stroke: comparison of the Stroke Impact Scale and Short Form-36.	Stroke	2003	yes	Community dwelling	no	yes	no	yes	no	no	yes	no
Defining post-stroke recovery: implications for design and interpretation of drug trials.	Neuropharmacology	2000	yes	Community dwelling	no	no	no	yes	yes	no	yes	no
Dependency and health utilities in stroke: Data to inform cost-effectiveness analyses.	European Stroke Journal	2017	yes	Randomly selected	no	no	no	no	yes	yes	yes	no
Psychometric properties of the German version of the health-related quality of life in stroke patients (HRQOLISP) instrument.	NeuroRehabilitation.	2013	yes	Community dwelling	no	no	no	no	no	no	yes	no
Psychometric properties of the Italian version of the stroke impact scale 3.0.	European Journal of Cardiovascular Nursing	2013	yes	Randomly selected	no	no	no	no	yes	no	yes	no
Self-and proxy-report agreement on the stroke impact scale.	Stroke	2009	yes	Randomly selected	no	no	no	yes	no	no	yes	no
Measuring preference-based quality of life using the euroqol EQ-5D in patients with cerebral aneurysms.	Neurosurgery	2009	yes	Community dwelling	no	no	no	yes	yes	yes	no	no



Recurrent stroke was associated with poor quality of life in patients with transient ischemic attack or minor stroke: Finding from the CHANCE trial.	CNS Neuroscience & Therapeutics	2014	yes	Randomly selected	no	no	no	yes	yes	yes	yes	no
The Stroke Impact Scale Version 2.0: Evaluation of reliability, validity, and sensitivity to change.	Stroke	1999	yes	Community dwelling	no	no	no	no	yes	no	yes	no
The combined impact of dependency on caregivers, disability, and coping strategy on quality of life after ischemic stroke.	Health & Quality of Life Outcomes	2019	no	Community dwelling	no	no	no	yes	no	yes	yes	yes
Quality of life and depression 3 months after intracerebral hemorrhage.	Brain and behavior	2019	yes	Community dwelling	no	no	yes	yes	yes	yes	yes	no
Utility-weighted modified Rankin Scale: Still too crude to be a truly patient-centric primary outcome measure?.	International Journal of Stroke	2019	yes	Randomly selected	no	yes	no	yes	yes	in original AVERT paper	yes	yes
PROMIS GH (Patient-reported outcomes measurement information system global health) scale in stroke a validation study.	Stroke	2018	yes	Community dwelling	no	yes	no	yes	yes	yes	yes	yes