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SYSTEMATIC REVIEW AND META-ANALYSIS

The Benefit of Dysphagia Screening in Adult Patients With Stroke: A Meta-Analysis

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BACKGROUND: Early identification of dysphagia aims to mitigate the risk of health consequences in adults poststroke; however, the evidence from experimental trials alone is inconclusive. This meta-analysis assessed dysphagia screening benefit from both trial and observational data.

METHODS AND RESULTS: Seven electronic databases were searched to December 2019. Unique abstracts and full articles were screened for eligibility by 2 independent blinded raters using a priori criteria and discrepancies resolved by consensus. Included studies were summarized descriptively and assessed for methodological quality using Cochrane Risk of Bias Tool. Across studies, pooled estimates of health benefit were derived for homogeneous data using Review Manger 5.3. From the yield of 8860 citations, 30 unique articles were selected: 24 observational and 6 randomized trials. Across studies, comparisons varied: no screening versus screening, late versus earlier screening, informal versus formal screening, pre- versus postscreening, and pre- versus poststroke guidelines that included screening. Pooled estimates across comparisons favored experimental groups for pneumonia odds ratio (OR), 0.57 (95% CI, 0.45–0.72), mortality OR, 0.52 (95% CI, 0.35–0.77), dependency OR, 0.54 (95% CI, 0.35–0.85), and length of stay standardized mean difference, −0.62 (95% CI, −1.05 to −0.20).

CONCLUSIONS: Combining evidence from experimental and observational studies derived a significant protective health benefit of dysphagia screening following adult acute stroke for pneumonia, mortality, dependency, and length of stay.

Key Words: dysphagia ■ early detection ■ health outcomes ■ screening ■ stroke

Dysphagia is common following stroke, affecting ≈55% of acute stroke patients,[1] and leads to complications such as aspiration pneumonia,[1] malnutrition,[2] dependency, and mortality.[1,3] There has been recent effort to promote early identification of dysphagia with screening as a critical first step to promote improved recovery.

Best practice stroke guidelines[4,5] state level 2 evidence to support early detection for screening, yet practice remains varied. Despite available psychometrically sound screening tools,[6] adherence to dysphagia screening across acute stroke institutions in both the United States and Canada has ranged from 56.7%[7] to 80.8%.[8] The current evidence, based on only randomized controlled trial (RCT) data, leaves the healthcare professional unclear as to best practice for patients with stroke. We posit that reviews limited to RCT data may have inadvertently overlooked more convincing clinical data.

To address the uncertainty related to dysphagia screening benefit in patients with stroke, we conducted a systematic review of the literature that extends beyond RCT data and also includes high-quality observational evidence. The specific aim of this study was to assess whether early detection for dysphagia with bedside screening administered to adult patients with stroke by a nondysphagia expert reduces the frequency of health-related complications such as pneumonia, dependency, mortality, and length of hospital stay (LOS) compared with similar patients with no or relatively less rigorous early detection.

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CLINICAL PERSPECTIVE

What Is New?

- New high-level evidence from meta-analysis data suggests health benefits from early dysphagia screening in adult patients diagnosed with acute stroke.

What Are the Clinical Implications?

- These findings support the use of dysphagia screening protocols applied early after stroke to mitigate unnecessary health consequences of pneumonia, mortality, dependency, and length of stay.

Nonstandard Abbreviations and Acronyms

SLP **speech-language pathologist**

METHODS

The data that support the findings of this study are available from the corresponding author upon request. This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses protocol[9] for treatment benefit and was not a candidate for institutional ethical review. Our search was directed by the following operational definitions: *stroke* included any stroke etiology; *dysphagia* was impaired swallow physiology of the upper aerodigestive tract; and *screening* was bedside testing by a clinician other than a speech-language pathology (SLP) dysphagia expert.

Search Methodology

An original search was conducted in 2013. We searched for relevant peer-reviewed abstracts in the following electronic databases: MEDLINE (1946–January 2013), PsycINFO (1806–January 2013), MEDLINE In-process (February 2013), EMBASE (1974–January 2013), CINAHL (1990–2013 February), Cochrane Database of Systematic Reviews (2005–December 2012), and Cochrane Central Register of Controlled Trials (January 2013). Across databases, the general search strategy included deglutition, deglutition disorders, dysphagia, swallowing, swallowing disorders, oropharyngeal, stroke, poststroke, cerebral vascular, screen, and early detection. This search was reproduced and expanded to include all literature published up to December 2019. All strategies were rerun using the same databases, with the exception of 1. CINAHL was replaced with EMCARE from Ovid, as the CINAHL database changed from the original search. Rather than omitting a database, we added EMCARE, which targets nursing and allied health. Other differences between the original and expanded search included (1) MEDLINE In-process expanded from original search to include e-publication ahead of print in reproduced search, and (2) a new subject heading "stroke rehabilitation" was added to the databases MEDLINE and EMBASE. The complete search strategy for MEDLINE for both the original and reproduced searches is detailed in Data S1. A manual search was also conducted in researchers' personal libraries. The yield across all data sources and from both searches were merged and duplicates removed resulting in a final unique citation count to December 2019.

Study Selection

Two independent raters excluded citations if they had no abstract; no human participants; were classified as a tutorial or review; were conference proceedings; had <10 eligible patients; had more than 10% of eligible subjects <18 years of age; had more than 10% of eligible subjects with a diagnosis other than stroke; made no mention of dysphagia screening and/or clinical assessment by a non-speech-language pathologist; or made no mention of a health-related outcome (such as pneumonia, nutrition/hydration, death or dependency, LOS). Discrepancies were resolved by consensus. All other abstracts were accepted and brought to full article review. Additional full article review exclusion criteria included no comparison outcome data between the 2 dysphagia screening groups and systematic reviews. Discrepancies for full article exclusion were resolved by consensus between the 2 raters who were blinded to one another's ratings. The kappa coefficient and associated 95% CI was calculated to determine interrater reliability at both the abstract and full article review phase. Studies included in related systematic reviews were included if they met our inclusion criteria and were unique to our yield.

Data Extraction

Data were extracted descriptively from included studies by 1 reviewer and cross-checked for accuracy by a second rater: sample size, age, sex, stroke type and severity, study design, control and experimental comparison details, dysphagia screening details, number of failed screenings, health outcome details, number with poor health outcomes by type, and, if reported, health outcome adjusted point estimates with 95% CIs. To identify homogenous subgroupings, studies were stratified by control and experimental comparison details.

Quality Assessment

All accepted studies were assessed for methodological quality by 1 reviewer and cross-checked by a second rater according to Cochrane's Risk of Bias

and included the following domains: selection bias, detection bias, attrition bias, and reporting bias.[10] Discrepancies were resolved by consensus.

Statistical Analysis

Homogeneous data related to the target outcomes were entered into RevMan, version 5.3.[11] For experimental groupings with varied screening time, we compared results between the earliest versus latest screen. For the same health outcome, a random effects model was used to derive the pooled estimates for ≥2 studies with similar control and experimental comparisons: first across homogeneous comparisons and then across all comparisons. For reported dichotomous raw outcome data we derived odds ratios (ORs) using the random effects model, whereas for reported continuous raw outcome data we derived the standardized mean differences. At the individual study level, odds ratios were calculated by using the standard equation based on 2×2 tables. All point estimates with 95% CIs were depicted using forest plots. Funnel plots were also produced of effect measures against the inverse of SE to assess for publication bias.

RESULTS

Literature Retrieved

The 2 searches yielded a combined total of 8860 citations. Following duplicate removal, 5996 unique abstracts were screened, of which 494 were accepted for full article review including 7 from related systematic reviews. At the abstract review stage, the kappa coefficient was 0.63 (95% CI, 0.60–0.67) and at the full article review stage, the kappa coefficient was 0.90 (95% CI, 0.77–1.04). Across all full articles screened, 33 articles were deemed eligible and moved forward. The 33 articles were based on 27 studies: 2 articles[12,13] from the HEADPOST (Head Position in Stroke Trial),[14] 3 articles[15–17] from the study by Middleton and colleagues,[17] 2 articles[18,19] from the study by Perry and McLaren,[18] 2 articles[20,21] by Svendsen and colleagues,[20] 2 articles[22,23] by Odderson and McKenna,[22] and 25 were unique studies (see Figure 1 for Preferred Reporting Items for Systematic Reviews and Meta-Analyses and Data S1 for list of excluded articles).

Characteristics of Included Studies

Of the 27 studies, 22 studies[3,19–22,24–39] were observational in design, and 5 studies[12,13,15–17,40,41] were RCTs. Of the observational studies, 10[*] assessed data from prospective stroke registries; 7 studies[†] used historical controls to compare screening intervention; 5 studies[27,28,36,42,43] assessed data from patient medical records, of which 3 studies[27,42,43] were from single institutions and 2 studies[28] from multiple hospital sites. Of all studies, 29.6% (n=8[‡]) were conducted in European countries and the sample sizes ranged from 101[25] to 143 578[34] participants. The combination of acute stroke type varied, with 2 articles from the same study but included different stroke types, thus 8 articles[§] with only ischemic and 18 articles[‖] with mixed ischemic and hemorrhagic strokes. Two studies[27,32] did not specify stroke type. Stroke severity was reported in 21 (77.8%) studies using 1 of 3 measures, namely National Institutes of Health Stroke Scale,[45] Canadian Neurological Scale,[46] or Intracerebral Hemorrhage Score.[47] Eleven studies reported overall median stroke severity scores ranging from mild[3,12,26,34,35] to moderate.[18,19,30,33,36,41] Five comparison groups evolved, which we stratified accordingly as no screening versus screening,[¶] late versus early screening,[3,16,21,26,29] informal versus formal screening,[30,41] pre- versus postscreening,[18,19,25,32–35,37,39,40] and pre- versus poststroke guideline that included screening[15,17,22,23,27,42,44] (see Table S1).

Results from articles using data from the same study were summarized together, unless the group comparisons were different. In the end, 30 articles reported unique data and were moved to data extraction.

Dysphagia Screening

Across all included articles, the dysphagia screening protocols used for early detection varied, with 14[#] declaring no specific tool, 4 articles[25,29,32,37,39,43] declaring an institution-specific protocol, 1 of which was composed of 2 bedside water swallowing tests[48,49] and only 12[**] using a previously published tool. Of the articles that used published screening tools: 6 articles[12,13,15–17,36,40] included the Acute Screening of Swallow in Stroke/Transient Ischemic Attack,[50] 4 articles[20,21,33,35,38] included the Gugging Swallowing Screen,[51] 1 article[39] used the Three-Step Swallowing Screen protocol,[48,49] and 1 used the MetroHealth Dysphagia Screen.[52] There was variation in who administered and interpreted the screening tools: 20 articles[††] reported a health professional such as a nurse or doctor, 12 of which[‡‡] clearly specified screening

*References 3, 20, 24, 26, 29–31, 34, 38, 39.

†References 18, 19, 22, 23, 25, 32, 33, 35, 37.

‡References 3, 20, 21, 24, 32, 33, 35, 38, 44.

§References 3, 12, 22, 23, 25, 30, 33, 35, 43.

‖References 13, 15–26, 28, 29, 31, 34, 36–42.

¶References 12, 13, 20, 24, 28, 31, 36, 38, 43.

#References 3, 18–24, 26–28, 30, 31, 34, 42, 44.

**References 12, 13, 15–17, 21, 33, 35–38, 40.

††References 3, 13, 16, 18, 19, 24–29, 31–34, 36, 37, 39, 41–44.

‡‡References 18, 19, 25, 26, 28, 29, 32–34, 36, 41–43.

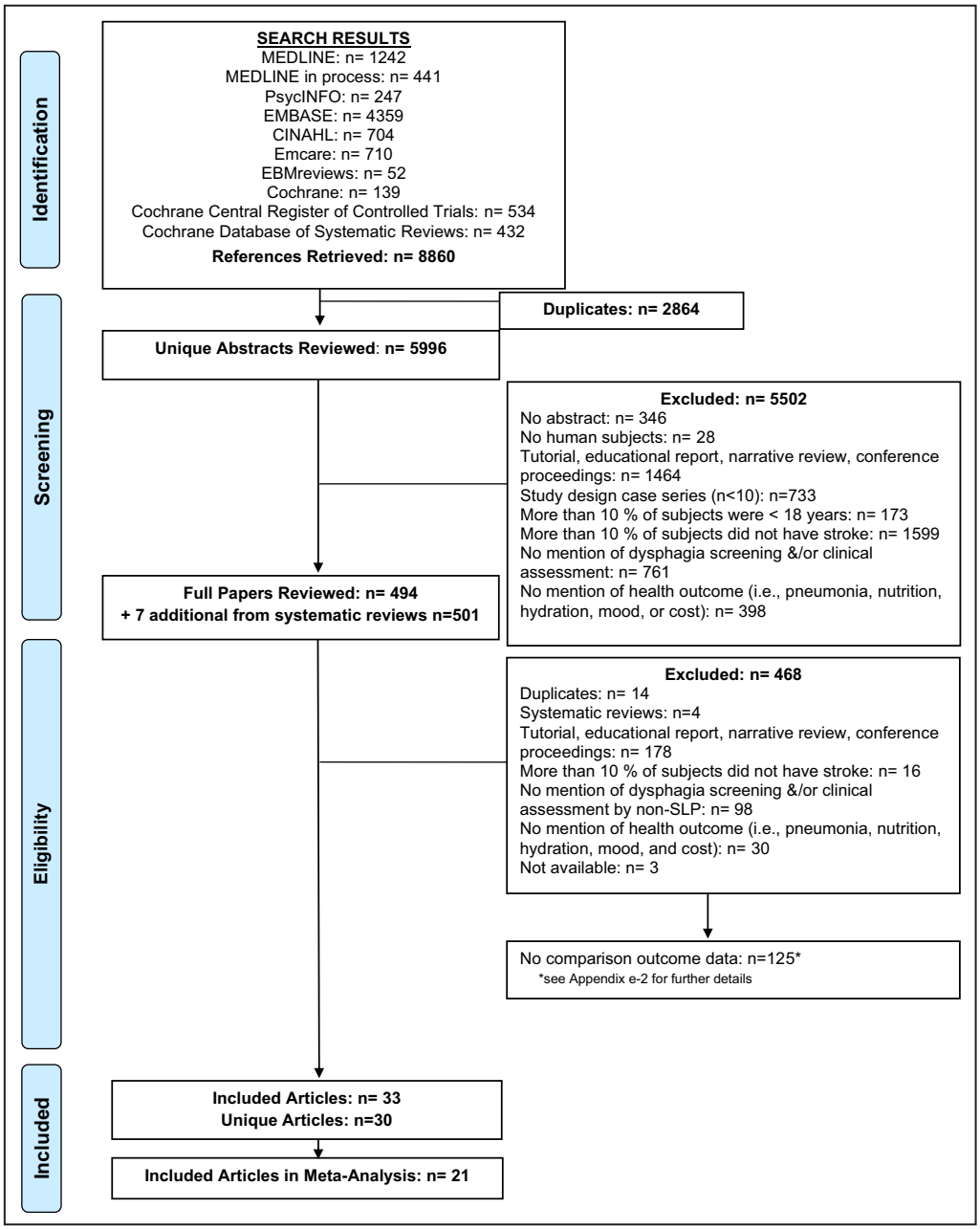

Figure 1. PRISMA flow diagram.
PRISMA indicates Preferred Reporting Items for Systematic Reviews and Meta-Analyses and SLP, speech-language pathologist.

training; 8 articles[12,15–17,22,23,30,38,40] specified that although SLPs were not the sole screener they were involved in dysphagia screening at various levels, of these 3 articles[12,15,17,40] used the Acute Screening of Swallow in Stroke/Transient Ischemic Attack[50] and 2 articles[35,38] the Gugging Swallowing Screen[51]; and the screener was unclear in 2 articles.[20,21]

Five articles compared late versus earlier screening: 3 articles[3,16,21] used a threshold of 24 hours; 1 article[29] <4 hours; and 1 article[26] <79 minutes. Two[30,41] articles compared informal screening without clear instruction versus formal screening with clear instruction. Nine articles compared standard care without screening (pre-) versus different screening experimental groups (post-), namely: 2 articles[25,32] provided additional training to screeners and 7 articles[18,19,33–35,37,39,40] implemented specific screening protocols. Likewise, 6 articles compared standard care without stroke guidelines (pre-) versus post-stroke guidelines that included screening at varying years post implementation: first year,[15,17,22,23,27,44] second year,[22,23,44] or third year.[42]

Screening Adherence

Adherence was relevant for the 20 articles[§§] that allocated screening to all patients in the experimental groups. Of these, 12 articles[‖] reported screening adherence, with rates that ranged from 18.2%[44] to 100.0%.[33]

Dysphagia Frequency

The incidence of dysphagia from screening results was reported in only 8 articles,[¶¶] with the frequency ranging from 20.5%[25] to 62.3%.[19]

Reported Health Outcomes

Across the 30 included articles, the benefit of dysphagia screening was measured with various health-related outcomes, including pneumonia in 20,[##] mortality in 18,[***] dependency in 13,[†††] and LOS in 13[‡‡‡] (see Table). Pneumonia was captured within hospital stay in 16 articles[§§§] but for the remaining 4 articles[22,23,28,42,43] time was not specified. Eleven articles[‖‖] identified pneumonia from both clinical and radiographic findings, 3 articles[25,26,44] from only clinical findings and 1 article[37] from only radiographic findings. Of the 20 articles that captured pneumonia, only 1 article[19] defined it broadly as infection, whereas all others[¶¶¶] were specific to infection secondary to aspiration.

Likewise, mortality was captured at varying time points: captured anytime within hospital stay in 13 articles[###]; 30 days poststroke in 3 articles[24,26,34]; 90 days poststroke in 5 articles[12,17,24,33,41]; 6 months poststroke in 1 article[42]; and, 3 to 5 years poststroke admission in 1 article.[15] Dependency was captured at discharge in 6 articles[3,18,19,25,29,41,42] and 90 days follow-up poststroke admission in 8 articles[3,12,13,16,17,33,40,41]; and captured using the Modified Rankin Scale[****] in 9 articles,[22] with varying impairment score cutoffs, at either 2[3,16] or 3.[12,13,29,41] Five articles[12,13,16,17,40] combined mortality and dependency as a composite score based on the Modified Rankin Scale and were stratified as a dependency outcome. The Barthel Index[††††] was used in 3 articles,[19,40,42] 1 of which[40] defined impairment as a dichotomous score of ≥95 and 2 articles[19,42] reported continuous data. Enteral feeding was captured as a surrogate measure of dependency in 1 article[31]. LOS was captured in 13 articles[17–23,29,33,35,39,41–44] and defined as the duration from stroke hospital admission to discharge. LOS was reported as a continuous outcome in 13 articles,[17–23,29,33,35,39,41–44] with mean and SD scores in 7 articles[17–19,21–23,39,43,44] and median and range scores in 5 articles[20,33,35,41,42]. One[29] article reported LOS as a dichotomous outcome with a cutoff score of 3 weeks.

Methodological Quality

Randomized Controlled Trials

The risk for selection bias was low across all RCTs but 1 article[41] that based assignment of patients to study arms on hospital ward at admission. All RCTs had high risk of detection bias as raters of dysphagia screening were not blinded to stroke severity[12,13,15–17,40,41] and/or health outcomes.[13,15–17,41] Risk for attrition bias was low for RCTs, with only 2 RCTs[15–17] at high risk owing to low accountability of all participants. All RCTs presented with high risk for reporting bias for dysphagia screening as they used tools previously reported to have insufficient reliability and validity.[6] Only 1 trial[40] provided sufficient detail enabling replication of the screening protocol. Three trials[12,13,41] did not report screening adherence. In contrast, the risk of reporting bias across all 6 RCTs was low with regard to health-related outcomes. All trials either operationally defined their outcomes or used measures that were previously proven reliable and accurate. Outcome data were not complete in 2 trials[16,17] and in 1 trial[12] it was unclear whether outcomes were identified using the same surveillance schedule across all patients.

Observational articles

The risk for selection bias was low as all observational articles specified inclusion criteria, and all but 6 clearly specified consecutive enrolment. There were 5 articles[25,30,32,38,44] articles that did not report data adjusted for covariates and thus presented with high risk of bias for differences between control and experimental groups. All observational articles had high risk of detection bias as no study reported rater blinding for dysphagia screening or health-related outcomes. Similar to RCTs, observational articles had low risk of attrition bias, with only 1 study[24] presenting with high risk of bias within this domain. All observational articles presented with high risk of reporting bias owing to poorly detailed screening protocols,[††††] use of screening tools

[§§]References 12, 13, 15–19, 22, 23, 25, 27, 30, 32–35, 37, 39–44.

[‖]References 15–19, 22, 23, 25, 27, 30, 32, 33, 40, 42, 44.

[¶¶]References 18, 19, 22, 23, 25, 32, 33, 35, 36.

[##]References 3, 13, 15, 17, 19, 25, 26, 28–30, 33–38, 41–43.

[***]References 12, 15, 17, 19, 24–27, 29, 30, 32–35, 37–39, 41, 42.

[†††]References 3, 12, 13, 16, 17, 19, 25, 29, 31, 33, 40–42.

[‡‡‡]References 17, 19–23, 29, 33, 35, 39, 41–44.

[§§§]References 3, 13, 15, 17–19, 25, 26, 29, 30, 33, 35–39, 41, 44.

[‖‖]References 3, 13, 17, 29, 30, 33, 35, 36, 38, 39, 41.

[¶¶¶]References 3, 13, 15, 17–19, 25, 26, 29, 30, 33, 35–39, 41, 44.

[###]References 3, 13, 15, 17–19, 25, 26, 29, 30, 33, 35–39, 41, 44.

[****]References 3, 12, 13, 16, 17, 29, 33, 40–42.

[††††]References 3, 18–20, 22–27, 30–32, 34, 42, 44.

Table. Criteria for Defining Health Outcomes

Study	Pneumonia*	Mortality	Dependency
No screening vs screening			
Abilleira et al, 2012[24]	N/A	30 and 90 d	N/A
Gonzalez-Suarez et al, 2018[28]	NR	N/A	N/A
Joundi et al, 2019† [31]	N/A	N/A	Enteral tube feeding dependency within hospital stay
Munoz-Venturelli et al, 2019[12]	N/A	90 d	mRS≥3[4] at 90 d
Ouyang et al, 2019[13]	Presence of 3 or more of following features: new or worsening cough, increased respiratory rate, oxygen desaturation, fever >38ºC, leukocytosis or leukopenia, and purulent secretions, rales or bronchial breath sounds with positive radiological abnormalities	N/A	mRS 3–6‡ at 90 d
Phan et al, 2019[36]	Clinical findings of: fever ≥38ºC, consolidation on cheat radiograph and use of antibiotic medications	N/A	N/A
Svendsen et al, 2009§ [20]	N/A	N/A	N/A
Rather et al, 2010[43]	NR	N/A	N/A
Teuschl et al, 2018[38]	Presence of clinical symptoms (eg, cough, purulent sputum) and clinical signs (eg, fever, rales, bronchial breath sounds or elevation of inflammatory markers in laboratory tests) confirmed by at least 1 chest radiograph within 7 d after stroke Hospital-associated pneumonia was defined as pneumonia diagnosed >7 d of admission	In hospital, on stroke unit	N/A
Late screening vs early screening			
Al-Khaled et al, 2016[3]	Based on a combination of clinical presentations, radiologic signs detected on a chest radiograph, and blood test results (C-reactive protein and leukocytes)	N/A	mRS ≥ 2–5 at discharge and at 90 d
Bray et al, 2017[26]	Stroke associated pneumonia was determined by physician and defined as the administration of antibiotics for a new clinical diagnosis of pneumonia <7 d after admission	30 d	N/A
Han et al, 2018[29]	Pneumonia was diagnosed by clinical examination that was supported and confirmed by biochemical, microbiological, and radiological evidence <7 d of admission	In hospital	mRS score of 3–5 at discharge
Middleton et al, 2019[16]	N/A	N/A	mRS ≥2[4] at 90 d
Svendsen et al, 2014‖ [21]	N/A	N/A	N/A
Informal screening vs formal screening			
Hinchey et al, 2005[30]	Either clinical finding of rales or dullness to discussion and 1 of the following: purulent sputum, isolation of organism, or chest radiograph showing evidence of infiltrate/consolidation/cavitation OR pleural effusion and 1 of following: purulent sputum, isolation of agent or antibody evidence of agent	In hospital	N/A
Rai et al, 2016[41]	Aspiration pneumonia was diagnosed if: (1) fever >38ºC, (2) purulent secretions/sputum, (3) pulmonary consolidation on physical examination, (4) presence of a new or progressive radiographic infiltrate, or (5) leukocytosis (>12 000/mm^3) or leukopenia (<4000/mm^3)	In hospital and 90 d	mRS at discharge and mRS ≤2 at 90 d

(*Continued*)

Table. Continued

Study	Pneumonia*	Mortality	Dependency
Prescreening vs postscreening			
Bravata et al, 2009[25]	Pneumonia events were identified based on medical record documentation of pneumonia diagnosis by clinician	In hospital	Functional status at discharge¶
Kampman et al, 2015[32]	N/A	In hospital; within 2 wk of admission	N/A
Lopes et al, 2018[33]	Presence of a pulmonary consolidation or infiltration in thoracic imaging and 3 or more of the following: fever ≥38ºC, productive cough, abnormal respiratory examination, arterial hypoxemia, elevation of blood inflammatory markers, and microbiological identification of a relevant pathogen	In hospital and 90 d	90 d mRS scores, cutoff not specified
Middleton et al, 2019[40]	N/A	N/A	Barthel Index score ≥95 (independence) at 90 d mRS ≥2[4] at 90 d
Paley et al, 2018[34]	N/A	30 d	N/A
Palli et al, 2017[35]	At least 1 of the following: fever >38ºC, leukopenia, and for adults ≥70 y, altered mental status with no recognized cause. At least 2 of the following: new onset of purulent sputum or increased respiratory secretions or increased suctioning requirements; new or worsening cough or dyspnea or tachypnea; rales, crackles or bronchial breath sounds; worsening gas exchange Positive chest x-ray examination was a prerequisite	In hospital	N/A
Perry & McLaren 2000[19]	Infectious rates included chest infections (diagnosed clinically by medical teams and treated with antibiotics), aspiration pneumonia or sepsis (treated with antibiotics)	In hospital	Barthel Index score at discharge
Schrock et al, 2018[37]	A new infiltrate on chest radiogram treated with antibiotics	In hospital	N/A
Yeh et al, 2011[39]	Nosocomial pneumonia: (1) rales in breathing sound examination or dullness in chest percussion or (2) radiological evidence of new infiltration, consolidation, cavitation, or pleural effusion, and at least 1 of the following: (1) new onset of purulent sputum, (2) positive blood culture, and (3) positive sputum culture	In hospital	N/A
Preguideline vs postguideline			
Burgess et al, 2012[42]	NR	In hospital and 6 mo	Barthel Index score at discharge
Di Matteo et al, 2004[27]	N/A	Death at disposition	N/A
Middleton et al, 2017[15]; 2011[17]	Discharge diagnosis was based on documentation of aspiration pneumonia (coding from *International Classification of Diseases, Tenth Revision*)	90 d and 3–5 y	mRS ≥2[4] at 90 d
Odderson et al, 1993[22]; 1995[23]	NR	N/A	N/A
Pinero-Saez et al, 2018[44]	Pneumonia diagnosis in medical discharge report	N/A	N/A

mRS indicates Modified Rankin Scale; N/A, not applicable; and NR, not reported.
*Time: within hospital stay unless otherwise specified.
†Only reported use of enteral feeding.
‡Includes combined dependency and mortality scores.
§Only reported length of hospital stay.
‖Only reported length of hospital stay.
¶Dichotomous outcome: functional=independent with all activities of daily living; not functional=not independent with all activities of daily living.

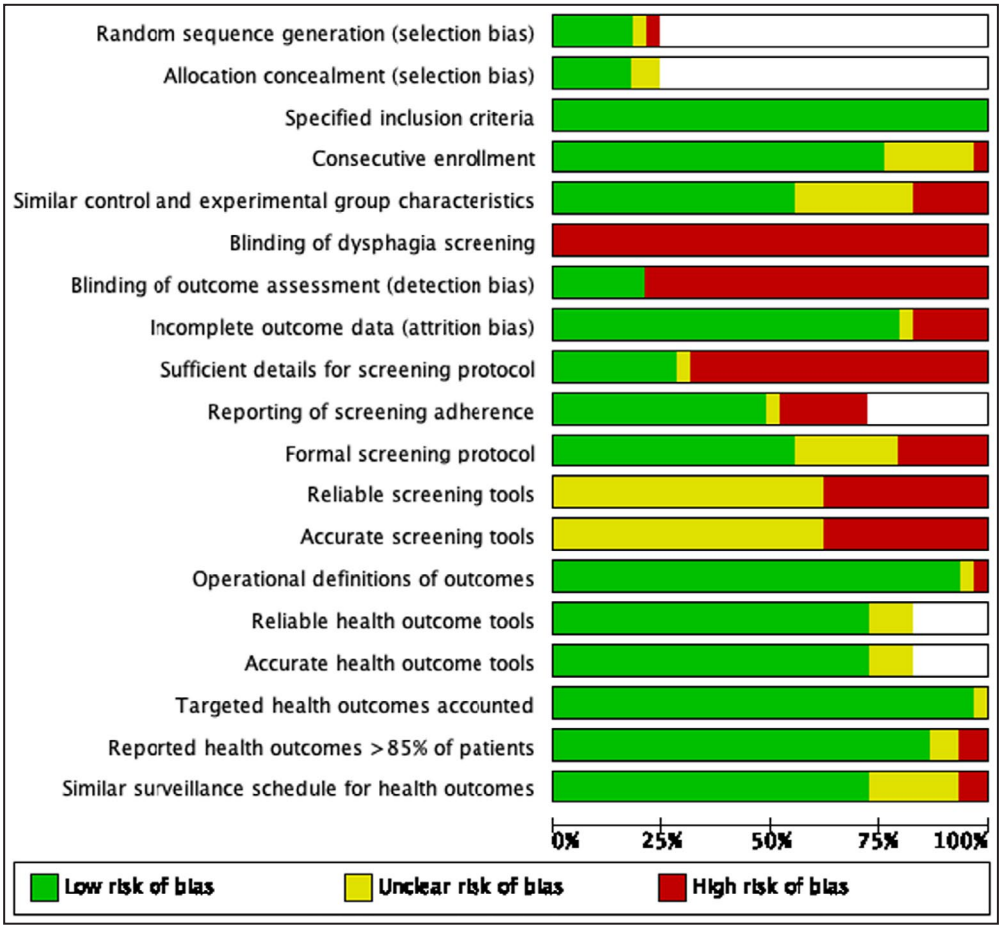

Figure 2. **Critical appraisal of included articles.**

that have not been shown reliable or valid,[21,27,33,35,38,39,42,43] and/or inconsistent screening protocols across study patients.[26,27,31,36,42] The risk of reporting bias for health-related outcomes was low. Across all articles, only 2 of them[35,37] were unclear whether surveillance schedules for health outcomes were similar for all patients, and only 1 article[19] was unclear on accountability of health outcomes (see Figure 2).

Screening Benefit to Health and Related Outcomes

The reported raw data and adjusted estimates between control and experimental groups for each comparison grouping is depicted descriptively (see Table S1). Of the 20 articles that reported pneumonia, 8 articles[3,13,26,28,29,33,39,41] reported adjusted estimates: 6 articles[3,26,28,29,39,41] favoring experimental groups and 2 articles[13,33] favoring control groups. Of all 18 articles that reported mortality, 7 reported adjusted estimates: 4 articles[12,15,29,41] favoring experimental group. Of all 13 articles that reported dependency, 5 articles[3,12,13,16,29] reported adjusted estimates, of which 3 articles[12,13,16] reported a composite score including dependency and mortality. All 5 favored the experimental group. Lastly, of all 13 articles that reported LOS, 2 articles[20,29] reported adjusted estimates for LOS, both favoring the experimental group.

Health-related outcomes were reported as raw data in 21 articles and were therefore pooled by outcome domain and comparison grouping for all articles (Figure 3A through 3D), and then for only the subgroup of articles that clearly specified screening was administered by a non-SLP dysphagia expert (Figure 4A through 4D). A random effects model was used based on the assumption that each sample came from a different population with different screening comparison groups and that the effects in the different populations may also differ. This analysis may have led to more conservative results.[55,56]

Pneumonia

The overall pooled OR for pneumonia events was 0.57 (95% CI, 0.45–0.72), favoring the experimental group

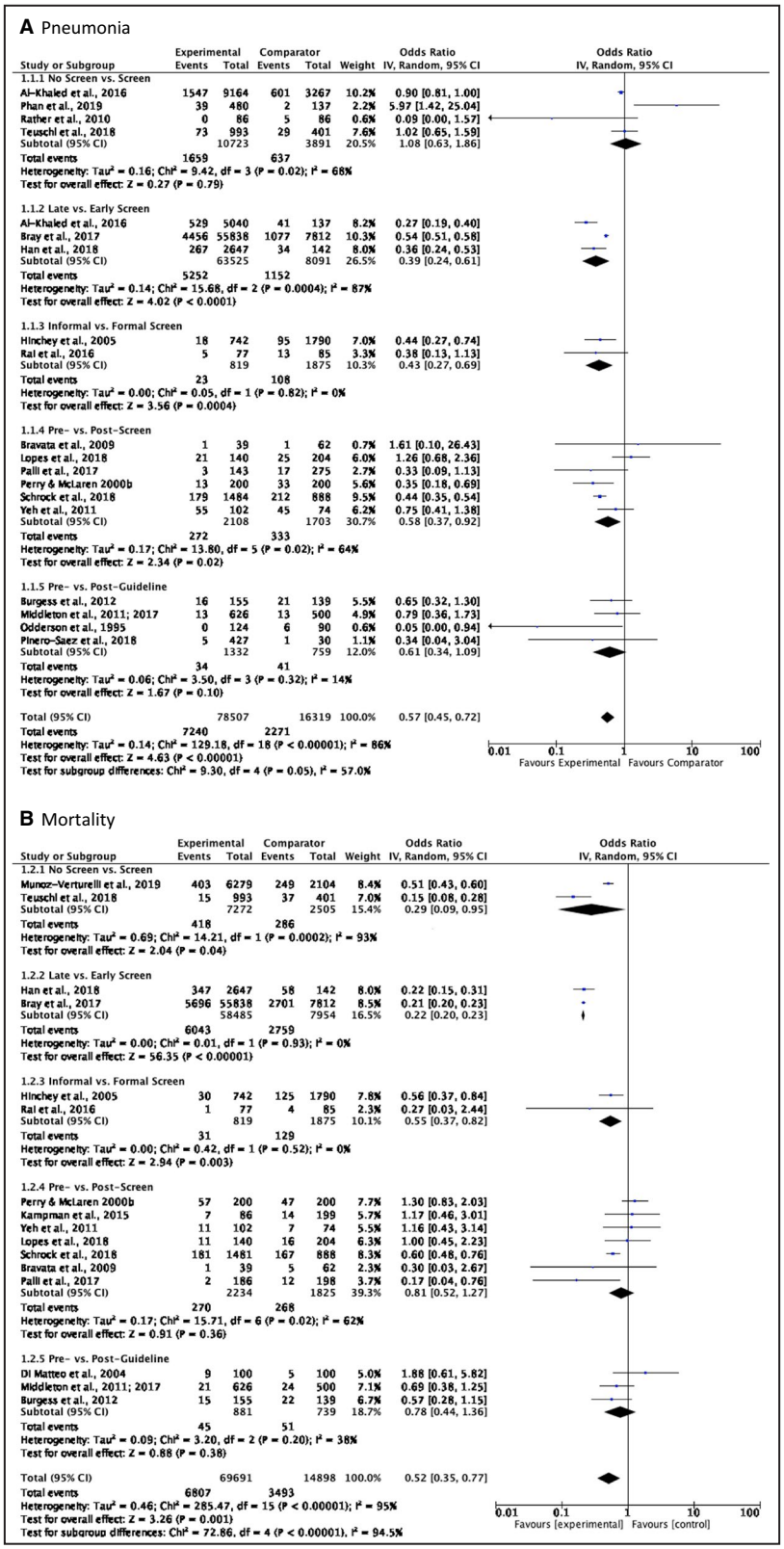

Figure 3. Meta-analysis of health outcomes.
A, Pneumonia; (**B**) mortality; (**C**) dependency; (**D**) length of hospital stay.

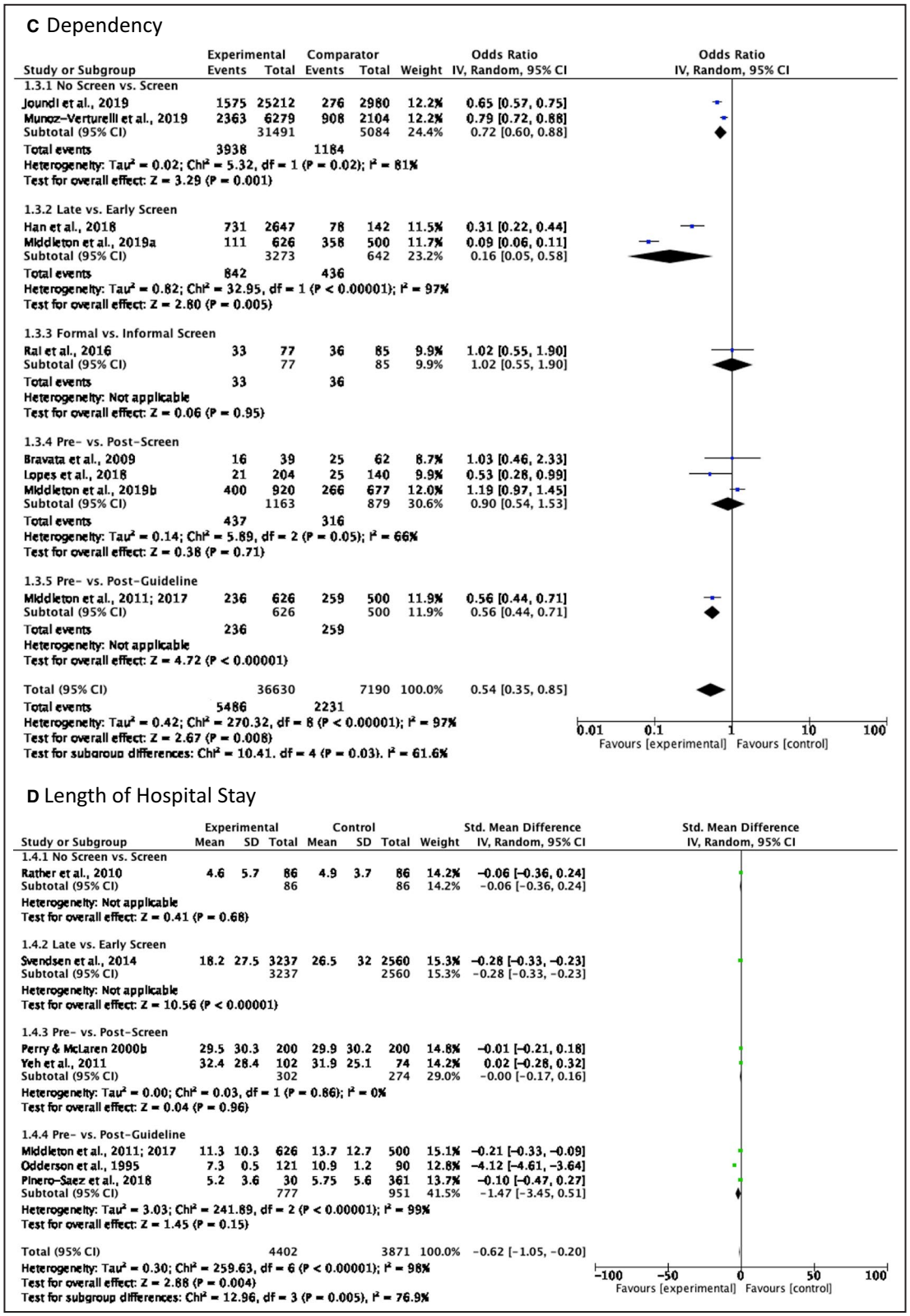

Figure 3 **Continued**

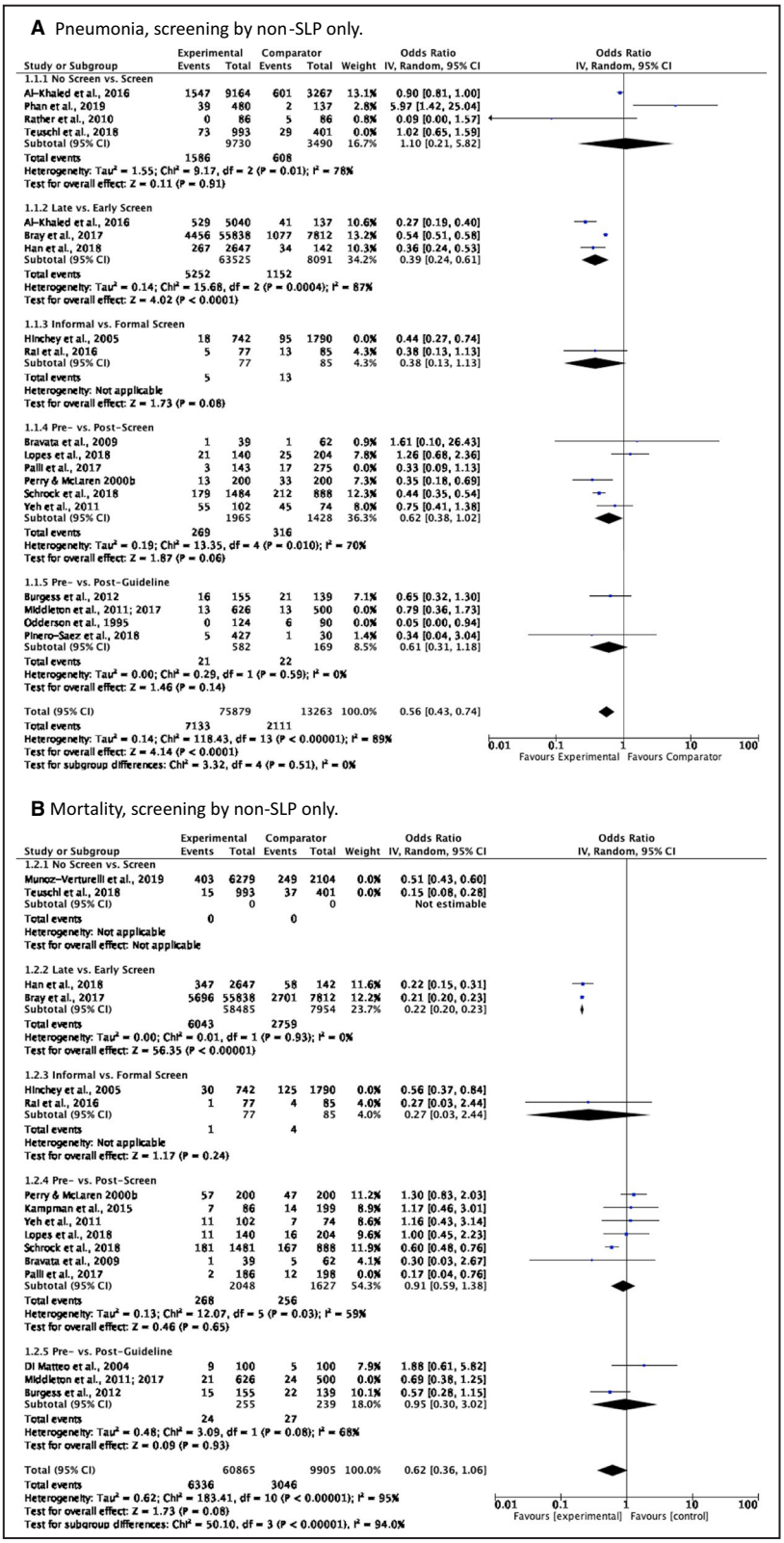

Figure 4. Meta-analysis of health outcomes, screening by non-SLP only.
A, Pneumonia, screening by non-SLP only; (**B**) mortality, screening by non-SLP only; (**C**) dependency, screening by non-SLP only; (**D**) length of hospital stay, screening by non-SLP only. SLP indicates speech-language pathologist.

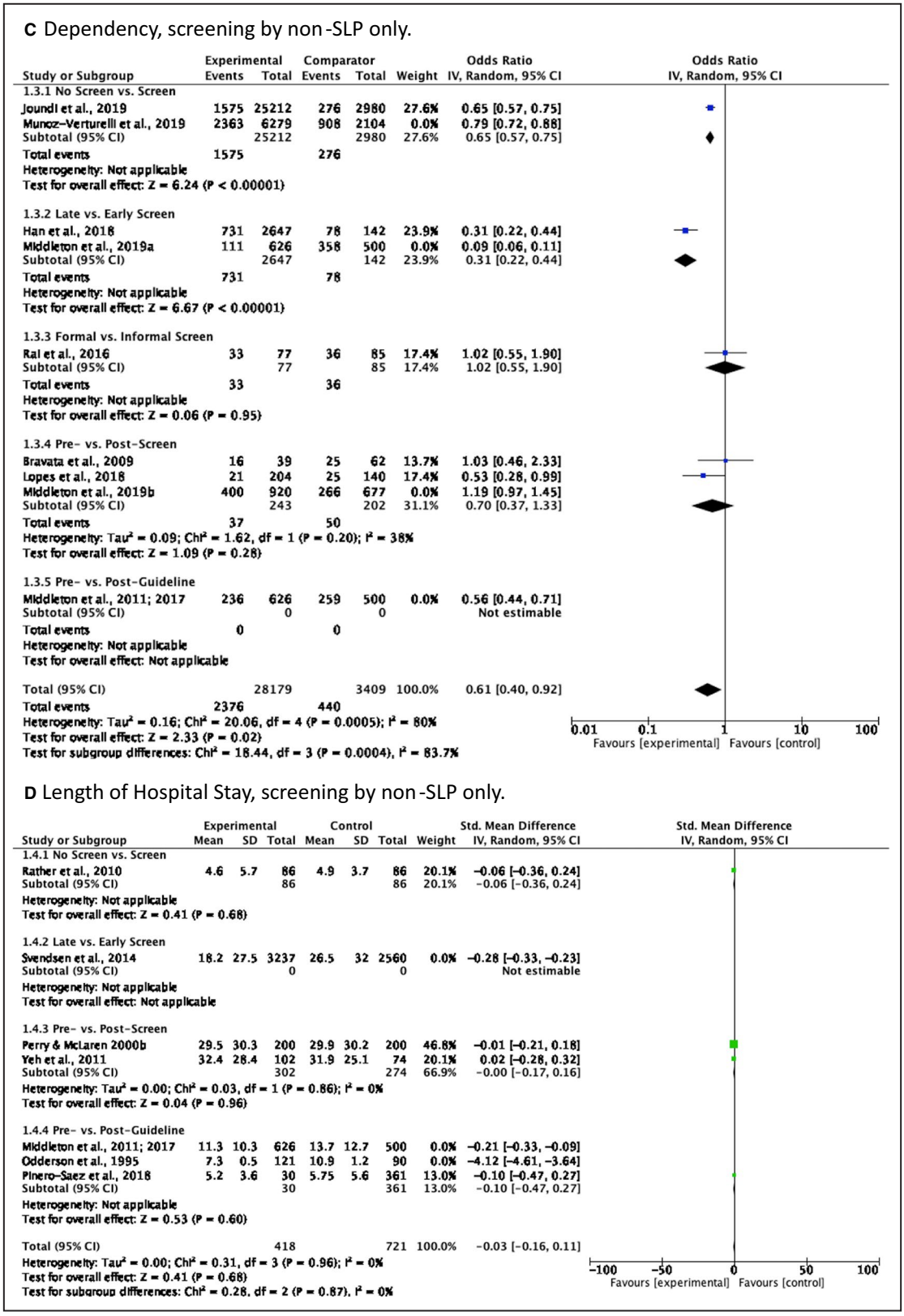

Figure 4. **Continued**

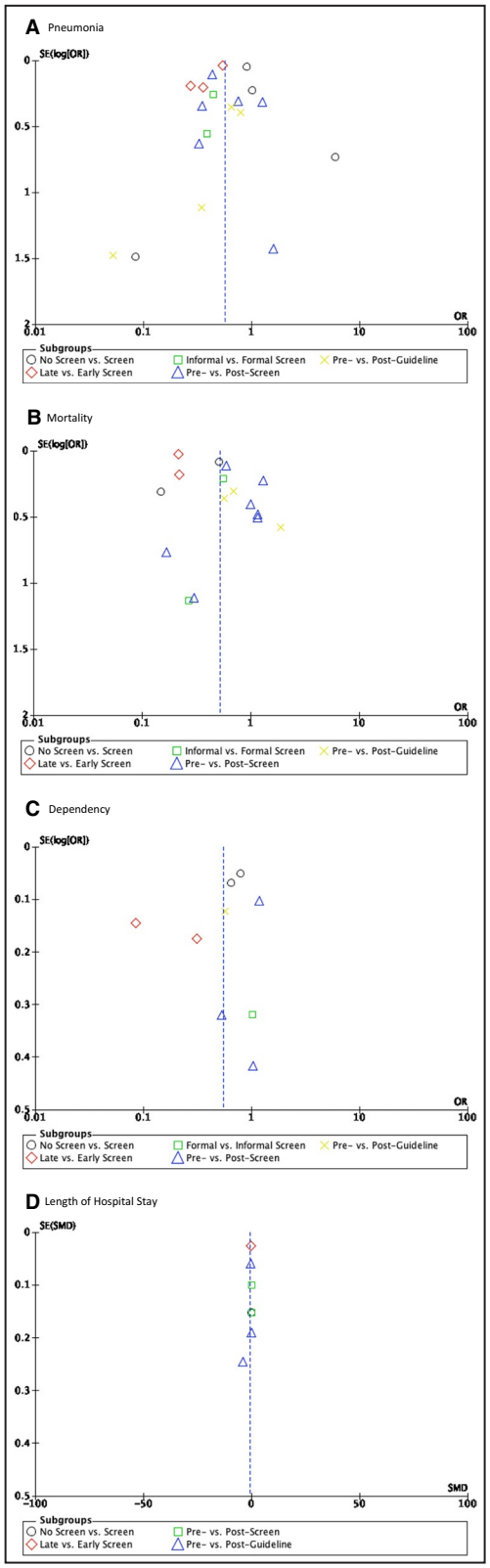

Figure 5. Funnel plots for health outcomes. **A**, Pneumonia; (**B**) mortality; (**C**) dependence; (**D**) length of hospital stay. OR indicates odds ratio; and SMD, standardized mean difference.

(see Figure 3A). However, within comparison grouping, results were mixed, with pooled ORs favoring the experimental group in only 3: late versus early screening (OR, 0.39; 95% CI, 0.24–0.61), informal versus formal screening (OR, 0.43; 95% CI, 0.27, 0.69), and pre- versus postscreening (OR, 0.58; 95% CI, 0.37–0.92). Likewise, the overall pooled effect for pneumonia in articles that clearly excluded SLPs as screeners also favored the experimental group with an overall OR of 0.56 (95% CI, 0.43–0.74) (see Figure 4A), with the pooled OR favoring the experimental group in only the late versus early screening subgroup (OR, 0.39; 95% CI, 0.24–0.61).

Mortality

The overall pooled OR for mortality was 0.52 (95% CI, 0.35–0.77), favoring the experimental group (see Figure 3B). However, similar to pneumonia, results within comparison groupings were mixed with only 3 favoring the experimental group: no screening versus screening (OR, 0.29; 95% CI, 0.09–0.95), late versus early screening (OR, 0.22; 95% CI, 0.20–0.23), and informal versus formal screening (OR, 0.55; 95% CI, 0.37–0.82). The overall pooled effect for mortality in articles that excluded SLPs as screeners did not significantly favor the experimental group although the late versus early screening comparison grouping did (OR, 0.22; 95% CI, 0.20–0.23) (see Figure 4B).

Dependency

The overall pooled OR for dependency was 0.54 (95% CI, 0.35, 0.85), favoring the experimental group (see Figure 3C). Results within comparison groupings were mixed with only 3 favoring the experimental group including no screening versus screening (OR, 0.72; 95% CI, 0.60–0.88), late versus early screening (OR, 0.16; 95% CI, 0.05–0.58) and pre- versus postguideline (OR, 0.56;, 95% CI, 0.44–0.71). Similarly, the overall pooled effect for articles that excluded SLPs as screeners favored the experimental groups (OR, 0.61; 95% CI, 0.40–0.92) with derived pooled estimates for 2 comparison groupings favoring the experimental group: no screening versus screening (OR, 0.65; 95% CI, 0.57–0.75), and late versus early screening (OR, 0.31; 95% CI, 0.22–0.44) (see Figure 4C).

Length of Hospital Stay

The overall pooled estimates for LOS favored the experimental group with a standardized mean difference of −0.62, (95% CI, −1.05 to −0.20). Results

within comparison groups were mixed with only early versus late screening favoring the experimental group (standardized mean difference = −0.28; 95% CI, −0.33 to −0.23). In contrast, the overall pooled effect or derived pooled estimates for comparison groupings for articles that excluded SLPs as screeners were not significant.

See Figure 5A through 5D for funnel plots. There was no obvious publication bias detected as represented visually by the symmetrical funnel plots.

DISCUSSION

The primary goal of this review was to systematically evaluate available evidence assessing the benefit of dysphagia screening on health outcomes in adults poststroke. Our findings yielded 30 unique articles, including 6 RCTs and 24 observational studies with 5 different comparison groupings. Despite the heterogeneity among study design and experimental groupings, and the risks for bias at the article level, our pooled estimates suggest that early dysphagia screening of adult patients admitted with acute stroke reduces their risk for pneumonia, mortality, overall dependency, and LOS.

Through meta-analysis, we identified pooled estimates favoring the experimental group for pneumonia, mortality, overall dependency, and LOS, which persisted for pneumonia and dependency within the subgroup of articles that included only non-SLP screeners. This finding provides support to practice guidelines[4,5] that advocate for screeners to receive training on tool administration and interpretation. Stroke guidelines recommend screening protocols that are reliable and valid, thereby serving to accurately identify patients at risk for dysphagia and prioritize their referral for a comprehensive dysphagia assessment by an SLP. Interestingly, of all the 30 retrieved articles only 12 used screening protocols with published protocols, none endorsed for sufficient reliably and validity.[6] Despite these limitations, our findings identified screening benefit to health outcomes poststroke when screening was offered soon after admission and by a trained screener.

Our findings of dysphagia screening benefit to health align with the work from others,[57] including 1 article[58] from our group published over 20 years ago. Our findings however contradict more recent suggestion of insufficient evidence.[59] Specifically, we identified 3 recently published trials[12,13,40] that showed benefit from screening on mortality and dependency, although not pneumonia. Furthermore, our inclusion of observational articles uniquely represented large stroke data sets and several multi-institutional findings. From these clinical studies we identified select features of dysphagia screening that benefit the health of patients with stroke, especially highlighting positive impact from earlier versus later screening. By virtue of its broader scope, our meta-analysis can perhaps be considered the first real-world assessment for the benefit of dysphagia screening in patients with stroke.

Despite our effort to maintain a rigorous literature review, there are methodological limitations in the available literature and within our methodology that are important to acknowledge. The high risk for detection and reporting bias within RCTs presents concern for study duplication. The bias most critical within observational articles was likely selection bias, in that the cohort comparison groupings may have offered screening to patients with more severe strokes types thereby disadvantaging the screened experimental group to more severe dysphagia and subsequently poorer health outcomes.[31,36,38] This potential bias might explain why some patients who were screened were at increased odds for dependency on enteral feeding.[31] Historical controls[18,19,22,23,35,37,44] captured data at 2 different time points presenting with high risk for bias related to differing potential confounding factors. Undoubtedly, these methodological limitations are serious considerations at the single article level, but perhaps by pooling their data across homogenous subgroupings of similar screening comparison groups, our analysis offers the first pragmatic evidence of screening benefit. In addition, there were some articles where it was unclear whether screening was by trained health professionals other than SLPs. It could be argued that a dysphagia screen by an SLP is not truly a screen but rather an assessment, so we thought it was important to stratify data by this feature. Interestingly, a clear benefit to health for both pneumonia and dependency persisted in the subgroup that clearly used trained nondysphagia experts.

CONCLUSIONS

Altogether, this meta-analysis provides novel findings that support the health outcome benefits of dysphagia screening in adults poststroke. This benefit was especially realized when screening was administered by trained screeners soon after admission to hospital. Critical next steps include comparing and contrasting existing psychometrically sound screening protocols to identify those that provide the most benefit to the health of patients with stroke. The findings from this study establish the necessary foundation for such a future clinical effectiveness trial.

ARTICLE INFORMATION

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Disclosures

R. Martino is the lead investigator and copyright holder of the dysphagia screening tool the Toronto Bedside Swallowing Screening Test (TOR-BSST)©. The remaining authors have no disclosures to report.

Supplementary Material

Data S1
Table S1
References 3, 12, 13, 15–44, 50, 51, 53–55

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SUPPLEMENTAL MATERIAL

Data S1.

Electronic Search Strategies

Database: Ovid MEDLINE(R) <1946 to January Week 3 2013>

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1 [Stroke Strategy] (0)
2 cerebrovascular disorders/ (42237)
3 exp basal ganglia cerebrovascular disease/ (321)
4 exp brain ischemia/ (75454)
5 exp carotid artery diseases/ (34990)
6 exp stroke/ (73683)
7 exp brain infarction/ (27196)
8 exp cerebral small vessel diseases/ (4070)
9 exp cerebrovascular trauma/ (4939)
10 hypoxia-ischemia, brain/ (3253)
11 exp intracranial arterial diseases/ (44292)
12 exp intracranial arteriovenous malformations/ (6749)
13 exp "Intracranial Embolism and Thrombosis"/ (17435)
14 exp intracranial hemorrhages/ (51711)
15 vasospasm, intracranial/ (2064)
16 vertebral artery dissection/ (768)
17 brain injuries/ (38880)
18 brain injury, chronic/ (522)
19 exp carotid arteries/ (46807)
20 endarterectomy, carotid/ (6306)
21 foramen ovale, patent/ (1116)
22 stroke.tw. (118029)
23 strokes.tw. (11805)
24 poststroke.tw. (2099)
25 post-stroke.tw. (2793)
26 cerebrovasc*.tw. (33032)
27 brain vasc*.tw. (665)
28 cerebral vasc*.tw. (5945)
29 cva*.tw. (2252)
30 apoplex*.tw. (2179)
31 isch?emi* attack*.tw. (8703)
32 tia*1.tw. (5546)
33 neurologic* deficit*.tw. (19500)
34 SAH.tw. (5780)
35 AVM.tw. (2955)
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37 (brain* adj5 infarct*).tw. (5298)
38 (brain* adj5 thrombo*).tw. (992)
39 (brain* adj5 emboli*).tw. (978)
40 (brain* adj5 occlus*).tw. (1032)

41 (brain* adj5 hypox*).tw. (4642)
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43 (brain* adj5 obstruction).tw. (81)
44 (brain* adj5 vasculopathy).tw. (37)
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74 (vertebrobasilar adj5 thrombo*).tw. (70)
75 (vertebrobasilar adj5 emboli*).tw. (37)
76 (vertebrobasilar adj5 occlus*).tw. (176)
77 (vertebrobasilar adj5 hypox*).tw. (1)
78 (vertebrobasilar adj5 vasospasm).tw. (14)
79 (vertebrobasilar adj5 obstruction).tw. (1)
80 (vertebrobasilar adj5 vasculopathy).tw. (2)
81 (hemispher* adj5 isch?emi*).tw. (1318)
82 (hemispher* adj5 infarct*).tw. (1156)
83 (hemispher* adj5 thrombo*).tw. (43)
84 (hemispher* adj5 emboli*).tw. (103)
85 (hemispher* adj5 occlus*).tw. (208)
86 (hemispher* adj5 hypox*).tw. (82)

87 (hemispher* adj5 vasospasm).tw. (9)
88 (hemispher* adj5 obstruction).tw. (7)
89 (hemispher* adj5 vasculopathy).tw. (1)
90 (intracran* adj5 isch?emi*).tw. (698)
91 (intracran* adj5 infarct*).tw. (400)
92 (intracran* adj5 thrombo*).tw. (873)
93 (intracran* adj5 emboli*).tw. (625)
94 (intracran* adj5 occlus*).tw. (891)
95 (intracran* adj5 hypox*).tw. (184)
96 (intracran* adj5 vasospasm).tw. (193)
97 (intracran* adj5 obstruction).tw. (99)
98 (intracran* adj5 vasculopathy).tw. (30)
99 (intracerebral adj5 isch?emi*).tw. (549)
100 (intracerebral adj5 infarct*).tw. (490)
101 (intracerebral adj5 thrombo*).tw. (245)
102 (intracerebral adj5 emboli*).tw. (98)
103 (intracerebral adj5 occlus*).tw. (75)
104 (intracerebral adj5 hypox*).tw. (24)
105 (intracerebral adj5 vasospasm).tw. (32)
106 (intracerebral adj5 obstruction).tw. (1)
107 (intracerebral adj5 vasculopathy).tw. (4)
108 (infratentorial adj5 isch?emi*).tw. (16)
109 (infratentorial adj5 infarct*).tw. (30)
110 (infratentorial adj5 thrombo*).tw. (3)
111 (infratentorial adj5 emboli*).tw. (1)
112 (infratentorial adj5 occlus*).tw. (3)
113 (infratentorial adj5 hypox*).tw. (0)
114 (infratentorial adj5 vasospasm).tw. (0)
115 (infratentorial adj5 obstruction).tw. (0)
116 (infratentorial adj5 vasculopathy).tw. (1)
117 (supratentorial adj5 isch?emi*).tw. (114)
118 (supratentorial adj5 infarct*).tw. (149)
119 (supratentorial adj5 thrombo*).tw. (8)
120 (supratentorial adj5 emboli*).tw. (9)
121 (supratentorial adj5 occlus*).tw. (6)
122 (supratentorial adj5 hypox*).tw. (2)
123 (supratentorial adj5 vasospasm).tw. (4)
124 (supratentorial adj5 obstruction).tw. (1)
125 (supratentorial adj5 vasculopathy).tw. (0)
126 (MCA adj5 isch?emi*).tw. (394)
127 (MCA adj5 infarct*).tw. (548)
128 (MCA adj5 thrombo*).tw. (113)
129 (MCA adj5 emboli*).tw. (101)
130 (MCA adj5 occlus*).tw. (1788)
131 (MCA adj5 hypox*).tw. (17)
132 (MCA adj5 vasospasm).tw. (44)

133 (MCA adj5 obstruction).tw. (16)
134 (MCA adj5 vasculopathy).tw. (2)
135 (anterior circulation adj5 isch?emi*).tw. (123)
136 (anterior circulation adj5 infarct*).tw. (156)
137 (anterior circulation adj5 thrombo*).tw. (14)
138 (anterior circulation adj5 emboli*).tw. (13)
139 (anterior circulation adj5 occlus*).tw. (41)
140 (anterior circulation adj5 hypox*).tw. (0)
141 (anterior circulation adj5 vasospasm).tw. (15)
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143 (anterior circulation adj5 vasculopathy).tw. (0)
144 (posterior circulation adj5 isch?emi*).tw. (167)
145 (posterior circulation adj5 infarct*).tw. (167)
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147 (posterior circulation adj5 emboli*).tw. (37)
148 (posterior circulation adj5 occlus*).tw. (45)
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150 (posterior circulation adj5 vasospasm).tw. (9)
151 (posterior circulation adj5 obstruction).tw. (0)
152 (posterior circulation adj5 vasculopathy).tw. (3)
153 (basal ganglia adj5 isch?emi*).tw. (122)
154 (basal ganglia adj5 infarct*).tw. (357)
155 (basal ganglia adj5 thrombo*).tw. (5)
156 (basal ganglia adj5 emboli*).tw. (10)
157 (basal ganglia adj5 occlus*).tw. (21)
158 (basal ganglia adj5 hypox*).tw. (38)
159 (basal ganglia adj5 vasospasm).tw. (2)
160 (basal ganglia adj5 obstruction).tw. (1)
161 (basal ganglia adj5 vasculopathy).tw. (10)
162 (lacunar adj5 infarct*).tw. (1838)
163 (cortical adj5 infarct*).tw. (1611)
164 (brain* adj5 haemorrhage*).tw. (610)
165 (brain* adj5 hemorrhage*).tw. (2760)
166 (brain* adj5 haematoma*).tw. (173)
167 (brain* adj5 hematoma*).tw. (689)
168 (brain* adj5 bleed*).tw. (363)
169 (cerebr* adj5 haemorrhage*).tw. (1700)
170 (cerebr* adj5 hemorrhage*).tw. (6523)
171 (cerebr* adj5 haematoma*).tw. (169)
172 (cerebr* adj5 hematoma*).tw. (813)
173 (cerebr* adj5 bleed*).tw. (840)
174 (cerebell* adj5 haemorrhage*).tw. (118)
175 (cerebell* adj5 hemorrhage*).tw. (671)
176 (cerebell* adj5 haematoma*).tw. (61)
177 (cerebell* adj5 hematoma*).tw. (226)
178 (cerebell* adj5 bleed*).tw. (52)

179 (intracerebral adj5 haemorrhage*).tw. (1295)
180 (intracerebral adj5 hemorrhage*).tw. (5894)
181 (intracerebral adj5 haematoma*).tw. (445)
182 (intracerebral adj5 hematoma*).tw. (1713)
183 (intracerebral adj5 bleed*).tw. (423)
184 (intracran* adj5 haemorrhage*).tw. (1424)
185 (intracran* adj5 hemorrhage*).tw. (5753)
186 (intracran* adj5 haematoma*).tw. (388)
187 (intracran* adj5 hematoma*).tw. (1096)
188 (intracran* adj5 bleed*).tw. (1426)
189 (parenchymal adj5 haemorrhage*).tw. (97)
190 (parenchymal adj5 hemorrhage*).tw. (460)
191 (parenchymal adj5 haematoma*).tw. (26)
192 (parenchymal adj5 hematoma*).tw. (184)
193 (parenchymal adj5 bleed*).tw. (126)
194 (intraventricular adj5 haemorrhage*).tw. (969)
195 (intraventricular adj5 hemorrhage*).tw. (3588)
196 (intraventricular adj5 haematoma*).tw. (38)
197 (intraventricular adj5 hematoma*).tw. (219)
198 (intraventricular adj5 bleed*).tw. (171)
199 (infratentorial adj5 haemorrhage*).tw. (10)
200 (infratentorial adj5 hemorrhage*).tw. (49)
201 (infratentorial adj5 haematoma*).tw. (7)
202 (infratentorial adj5 hematoma*).tw. (20)
203 (infratentorial adj5 bleed*).tw. (6)
204 (supratentorial adj5 haemorrhage*).tw. (59)
205 (supratentorial adj5 hemorrhage*).tw. (209)
206 (supratentorial adj5 haematoma*).tw. (38)
207 (supratentorial adj5 hematoma*).tw. (100)
208 (supratentorial adj5 bleed*).tw. (12)
209 (basal gangli* adj5 haemorrhage*).tw. (35)
210 (basal gangli* adj5 hemorrhage*).tw. (174)
211 (basal gangli* adj5 haematoma*).tw. (24)
212 (basal gangli* adj5 hematoma*).tw. (71)
213 (basal gangli* adj5 bleed*).tw. (25)
214 (subarachnoid adj5 haemorrhage*).tw. (3128)
215 (subarachnoid adj5 hemorrhage*).tw. (12115)
216 (subarachnoid adj5 haematoma*).tw. (93)
217 (subarachnoid adj5 hematoma*).tw. (419)
218 (subarachnoid adj5 bleed*).tw. (356)
219 (putaminal adj5 haemorrhage*).tw. (30)
220 (putaminal adj5 hemorrhage*).tw. (242)
221 (putaminal adj5 haematoma*).tw. (10)
222 (putaminal adj5 hematoma*).tw. (53)
223 (putaminal adj5 bleed*).tw. (4)
224 (putamen adj5 haemorrhage*).tw. (3)

225 (putamen adj5 hemorrhage*).tw. (36)
226 (putamen adj5 haematoma*).tw. (4)
227 (putamen adj5 hematoma*).tw. (15)
228 (putamen adj5 bleed*).tw. (1)
229 (posterior fossa adj5 haemorrhage*).tw. (30)
230 (posterior fossa adj5 hemorrhage*).tw. (136)
231 (posterior fossa adj5 haematoma*).tw. (58)
232 (posterior fossa adj5 hematoma*).tw. (232)
233 (posterior fossa adj5 bleed*).tw. (18)
234 (brain adj5 aneurysm*).tw. (665)
235 (cerebral adj5 aneurysm*).tw. (6412)
236 (intracranial adj5 aneurysm*).tw. (6935)
237 (communicating adj5 aneurysm*).tw. (1467)
238 (giant adj5 aneurysm*).tw. (2760)
239 (basilar adj5 aneurysm*).tw. (1107)
240 (vertebral artery adj5 aneurysm*).tw. (522)
241 (berry adj5 aneurysm*).tw. (231)
242 (saccular adj5 aneurysm*).tw. (2064)
243 (ruptured adj5 aneurysm*).tw. (7747)
244 vertebral artery dissection.tw. (473)
245 cerebral art* disease*.tw. (95)
246 (brain adj5 (vascular adj5 disease*)).tw. (407)
247 (intracranial adj5 (vascular adj5 disease*)).tw. (141)
248 (basal ganglia adj5 (vascular adj5 disease*)).tw. (4)
249 (lenticulostriate adj5 (vascular adj5 disease*)).tw. (0)
250 (brain adj5 (vascular adj5 disorder)).tw. (16)
251 (intracranial adj5 (vascular adj5 disorder)).tw. (5)
252 (basal ganglia adj5 (vascular adj5 disorder)).tw. (1)
253 (lenticulostriate adj5 (vascular adj5 disorder)).tw. (0)
254 (brain adj5 (vascular adj5 accident)).tw. (23)
255 (intracranial adj5 (vascular adj5 accident)).tw. (1)
256 (basal ganglia adj5 (vascular adj5 accident)).tw. (0)
257 (lenticulostriate adj5 (vascular adj5 accident)).tw. (0)
258 (brain adj5 (vascular adj5 injur*)).tw. (178)
259 (intracranial adj5 (vascular adj5 injur*)).tw. (32)
260 (basal ganglia adj5 (vascular adj5 injur*)).tw. (1)
261 (lenticulostriate adj5 (vascular adj5 injur*)).tw. (0)
262 (brain adj5 (vascular adj5 trauma*)).tw. (101)
263 (intracranial adj5 (vascular adj5 trauma*)).tw. (19)
264 (basal ganglia adj5 (vascular adj5 trauma*)).tw. (0)
265 (lenticulostriate adj5 (vascular adj5 trauma*)).tw. (0)
266 (brain adj5 (vascular adj5 insult)).tw. (8)
267 (intracranial adj5 (vascular adj5 insult)).tw. (2)
268 (basal ganglia adj5 (vascular adj5 insult)).tw. (2)
269 (lenticulostriate adj5 (vascular adj5 insult)).tw. (0)
270 (brain adj5 (vascular adj5 event)).tw. (3)

271 (intracranial adj5 (vascular adj5 event)).tw. (1)
272 (basal ganglia adj5 (vascular adj5 event)).tw. (0)
273 (lenticulostriate adj5 (vascular adj5 event)).tw. (0)
274 (isch?emic adj5 event).tw. (1655)
275 (isch?emic adj5 events).tw. (5125)
276 (isch?emic adj5 insult).tw. (3268)
277 (isch?emic adj5 attack*).tw. (8865)
278 (apoplectic adj5 event).tw. (12)
279 (apoplectic adj5 events).tw. (3)
280 (apoplectic adj5 insult).tw. (29)
281 (apoplectic adj5 attack*).tw. (25)
282 (cerebral vein adj5 thrombo*).tw. (198)
283 (cerebral venous adj5 thrombo*).tw. (1448)
284 (sinus adj5 thrombo*).tw. (3041)
285 (sagittal adj5 thrombo*).tw. (517)
286 CVDST.tw. (6)
287 CVT.tw. (638)
288 (intracranial adj5 stenosis).tw. (703)
289 (intracranial adj5 isch?emia).tw. (276)
290 (intracranial adj5 insufficiency).tw. (39)
291 (intracranial adj5 arteriosclero*).tw. (18)
292 (intracranial adj5 atherosclero*).tw. (499)
293 (intracranial adj5 occlus*).tw. (885)
294 (cerebral art* adj5 stenosis).tw. (456)
295 (cerebral art* adj5 isch?emia).tw. (746)
296 (cerebral art* adj5 insufficiency).tw. (43)
297 (cerebral art* adj5 arteriosclero*).tw. (456)
298 (cerebral art* adj5 atherosclero*).tw. (207)
299 (cerebral art* adj5 occlus*).tw. (8235)
300 (basilar art* adj5 stenosis).tw. (129)
301 (basilar art* adj5 isch?emia).tw. (36)
302 (basilar art* adj5 insufficiency).tw. (64)
303 (basilar art* adj5 arteriosclero*).tw. (8)
304 (basilar art* adj5 atherosclero*).tw. (48)
305 (basilar art* adj5 occlus*).tw. (567)
306 (vertebral art* adj5 stenosis).tw. (352)
307 (vertebral art* adj5 isch?emia).tw. (68)
308 (vertebral art* adj5 insufficiency).tw. (82)
309 (vertebral art* adj5 arteriosclero*).tw. (11)
310 (vertebral art* adj5 atherosclero*).tw. (78)
311 (vertebral art* adj5 occlus*).tw. (707)
312 (vertebrobasilar adj5 stenosis).tw. (82)
313 (vertebrobasilar adj5 isch?emia).tw. (223)
314 (vertebrobasilar adj5 insufficiency).tw. (561)
315 (vertebrobasilar adj5 arteriosclero*).tw. (5)
316 (vertebrobasilar adj5 atherosclero*).tw. (37)

317 (vertebrobasilar adj5 occlus*).tw. (176)
318 (vertebral basilar adj5 stenosis).tw. (4)
319 (vertebral basilar adj5 isch?emia).tw. (7)
320 (vertebral basilar adj5 insufficiency).tw. (58)
321 (vertebral basilar adj5 arteriosclero*).tw. (1)
322 (vertebral basilar adj5 atherosclero*).tw. (2)
323 (vertebral basilar adj5 occlus*).tw. (13)
324 (venous adj5 malformation*).tw. (1659)
325 (arteriovenous adj5 malformation*).tw. (9036)
326 (brain vasc* adj5 malformation*).tw. (19)
327 (brain adj5 angioma*).tw. (225)
328 (brain adj5 hemangioma*).tw. (94)
329 (brain adj5 haemangioma*).tw. (11)
330 (cerebral adj5 angioma*).tw. (423)
331 (cerebral adj5 hemangioma*).tw. (60)
332 (cerebral adj5 haemangioma*).tw. (16)
333 carotid*.tw. (79560)
334 patent foramen ovale.tw. (2865)
335 PFO.tw. (1321)
336 asymptomatic cervical bruit.tw. (12)
337 exp aphasia/ (9390)
338 anomia/ (893)
339 hemiplegia/ (9927)
340 hemianopsia/ (2310)
341 exp paresis/ (5340)
342 dysarthria/ (1693)
343 pseudobulbar palsy/ (82)
344 muscle spasticity/ (6279)
345 aphasi*.tw. (9495)
346 apraxi*.tw. (2579)
347 dysphasi*.tw. (1016)
348 dysarthri*.tw. (3568)
349 hemipleg*.tw. (7608)
350 hemipar*.tw. (8573)
351 paresis.tw. (7152)
352 paretic.tw. (1735)
353 hemianop*.tw. (2399)
354 hemineglect.tw. (277)
355 spasticity.tw. (6481)
356 anomi*.tw. (799)
357 dysnomi*.tw. (46)
358 acquired brain injur*.tw. (822)
359 hemiball*.tw. (462)
360 (unilateral adj5 neglect).tw. (831)
361 (visual adj5 neglect).tw. (628)
362 (hemispatial adj5 neglect).tw. (365)

363 (attentional adj5 neglect).tw. (117)
364 (spatial adj5 neglect).tw. (827)
365 or/2-364 (488305)
366 aneurysm, ruptured/ (5030)
367 exp brain/ (908842)
368 366 and 367 (407)
369 365 or 368 (488307)
370 [Dysphagia Strategy] (0)
371 exp deglutition disorders/ (38334)
372 deglut*.mp. (19885)
373 swallow*.mp. (17101)
374 dysphag*.mp. (15191)
375 VSS.mp. (1644)
376 VFSS.mp. (89)
377 FEES.mp. (19803)
378 FEEST.mp. (4)
379 371 or 372 or 373 or 374 or 375 or 376 or 377 or 378 (80419)
380 [Screening Strategy] (0)
381 exp Mass Screening/ (92762)
382 screen*.tw. (383505)
383 assess*.tw. (1448848)
384 (early adj2 identification).tw. (7230)
385 (early adj2 identify).tw. (1495)
386 (earlier adj2 identification).tw. (426)
387 (earlier adj2 identify).tw. (80)
388 (early adj2 evaluat*).tw. (4481)
389 (earlier adj2 evaluat*).tw. (322)
390 (early adj2 examine).tw. (434)
391 (early adj2 examinat*).tw. (1086)
392 (earlier adj2 examine).tw. (26)
393 (earlier adj2 examinat*).tw. (213)
394 (early adj2 detect*).tw. (43148)
395 (earlier adj2 detect*).tw. (3230)
396 (early adj2 diagnos*).tw. (54996)
397 (earlier adj2 diagnos*).tw. (4687)
398 (advanced adj2 detection).tw. (202)
399 (advance adj2 detect*).tw. (62)
400 (early adj2 investigat*).tw. (2909)
401 (earlier adj2 investigat*).tw. (1407)
402 (nursing adj2 test*).tw. (315)
403 (water adj2 swallow*).tw. (315)
404 (swallow* adj2 test*).tw. (273)
405 (liquid adj2 swallow*).tw. (164)
406 or/381-405 (1890134)
407 379 and 406 (10612)
408 369 and 407 (741)

409 limit 408 to yr="1990 -Current" (718)

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1 [Stroke Strategy] (0)
2 stroke.tw,kf. (28594)
3 strokes.tw,kf. (2318)
4 poststroke.tw. (575)
5 post-stroke.tw. (1485)
6 cerebrovasc*.tw,kf. (5221)
7 brain vasc*.tw. (139)
8 cerebral vasc*.tw. (623)
9 cva*.tw. (523)
10 apoplex*.tw. (268)
11 isch?emi* attack*.tw. (1394)
12 tia*1.tw. (1171)
13 neurologic* deficit*.tw. (3885)
14 SAH.tw. (1106)
15 AVM.tw. (654)
16 (brain* adj5 isch?emi*).tw. (2147)
17 (brain* adj5 infarct*).tw. (762)
18 (brain* adj5 thrombo*).tw. (109)
19 (brain* adj5 emboli*).tw. (137)
20 (brain* adj5 occlus*).tw. (105)
21 (brain* adj5 hypox*).tw. (539)
22 (brain* adj5 vasospasm).tw. (26)
23 (brain* adj5 obstruction).tw. (22)
24 (brain* adj5 vasculopathy).tw. (11)
25 (cerebr* adj5 isch?emi*).tw. (3579)

26 (cerebr* adj5 infarct*).tw. (2251)
27 (cerebr* adj5 thrombo*).tw. (1042)
28 (cerebr* adj5 emboli*).tw. (734)
29 (cerebr* adj5 occlus*).tw. (1642)
30 (cerebr* adj5 hypox*).tw. (224)
31 (cerebr* adj5 vasospasm).tw. (333)
32 (cerebr* adj5 obstruction).tw. (40)
33 (cerebr* adj5 vasculopathy).tw. (60)
34 (cerebell* adj5 isch?emi*).tw. (42)
35 (cerebell* adj5 infarct*).tw. (185)
36 (cerebell* adj5 thrombo*).tw. (34)
37 (cerebell* adj5 emboli*).tw. (20)
38 (cerebell* adj5 occlus*).tw. (18)
39 (cerebell* adj5 hypox*).tw. (3)
40 (cerebell* adj5 vasospasm).tw. (2)
41 (cerebell* adj5 obstruction).tw. (3)
42 (cerebell* adj5 vasculopathy).tw. (4)
43 (cortical adj5 isch?emi*).tw. (118)
44 (cortical adj5 infarct*).tw. (180)
45 (cortical adj5 thrombo*).tw. (66)
46 (cortical adj5 emboli*).tw. (10)
47 (cortical adj5 occlus*).tw. (27)
48 (cortical adj5 hypox*).tw. (28)
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50 (cortical adj5 obstruction).tw. (5)
51 (cortical adj5 vasculopathy).tw. (1)
52 (vertebrobasilar adj5 isch?emi*).tw. (36)
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69 (hemispher* adj5 vasculopathy).tw. (0)
70 (intracran* adj5 isch?emi*).tw. (178)
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72 (intracran* adj5 thrombo*).tw. (148)
73 (intracran* adj5 emboli*).tw. (195)
74 (intracran* adj5 occlus*).tw. (206)
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131 (posterior circulation adj5 obstruction).tw. (0)
132 (posterior circulation adj5 vasculopathy).tw. (0)
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136 (basal ganglia adj5 emboli*).tw. (2)
137 (basal ganglia adj5 occlus*).tw. (5)
138 (basal ganglia adj5 hypox*).tw. (4)
139 (basal ganglia adj5 vasospasm).tw. (1)
140 (basal ganglia adj5 obstruction).tw. (0)
141 (basal ganglia adj5 vasculopathy).tw. (5)
142 (lacunar adj5 infarct*).tw. (236)
143 (cortical adj5 infarct*).tw. (180)
144 (brain* adj5 haemorrhage*).tw. (97)
145 (brain* adj5 hemorrhage*).tw. (575)
146 (brain* adj5 haematoma*).tw. (11)
147 (brain* adj5 hematoma*).tw. (112)
148 (brain* adj5 bleed*).tw. (80)
149 (cerebr* adj5 haemorrhage*).tw. (200)
150 (cerebr* adj5 hemorrhage*).tw. (841)
151 (cerebr* adj5 haematoma*).tw. (12)
152 (cerebr* adj5 hematoma*).tw. (104)
153 (cerebr* adj5 bleed*).tw. (146)
154 (cerebell* adj5 haemorrhage*).tw. (19)
155 (cerebell* adj5 hemorrhage*).tw. (122)
156 (cerebell* adj5 haematoma*).tw. (6)
157 (cerebell* adj5 hematoma*).tw. (27)
158 (cerebell* adj5 bleed*).tw. (7)
159 (intracerebral adj5 haemorrhage*).tw. (197)
160 (intracerebral adj5 hemorrhage*).tw. (1444)
161 (intracerebral adj5 haematoma*).tw. (28)
162 (intracerebral adj5 hematoma*).tw. (183)
163 (intracerebral adj5 bleed*).tw. (56)

164 (intracran* adj5 haemorrhage*).tw. (228)
165 (intracran* adj5 hemorrhage*).tw. (1243)
166 (intracran* adj5 haematoma*).tw. (22)
167 (intracran* adj5 hematoma*).tw. (161)
168 (intracran* adj5 bleed*).tw. (379)
169 (parenchymal adj5 haemorrhage*).tw. (14)
170 (parenchymal adj5 hemorrhage*).tw. (85)
171 (parenchymal adj5 haematoma*).tw. (5)
172 (parenchymal adj5 hematoma*).tw. (33)
173 (parenchymal adj5 bleed*).tw. (20)
174 (intraventricular adj5 haemorrhage*).tw. (112)
175 (intraventricular adj5 hemorrhage*).tw. (541)
176 (intraventricular adj5 haematoma*).tw. (3)
177 (intraventricular adj5 hematoma*).tw. (41)
178 (intraventricular adj5 bleed*).tw. (19)
179 (infratentorial adj5 haemorrhage*).tw. (2)
180 (infratentorial adj5 hemorrhage*).tw. (9)
181 (infratentorial adj5 haematoma*).tw. (0)
182 (infratentorial adj5 hematoma*).tw. (7)
183 (infratentorial adj5 bleed*).tw. (0)
184 (supratentorial adj5 haemorrhage*).tw. (7)
185 (supratentorial adj5 hemorrhage*).tw. (36)
186 (supratentorial adj5 haematoma*).tw. (1)
187 (supratentorial adj5 hematoma*).tw. (21)
188 (supratentorial adj5 bleed*).tw. (3)
189 (basal gangli* adj5 haemorrhage*).tw. (8)
190 (basal gangli* adj5 hemorrhage*).tw. (51)
191 (basal gangli* adj5 haematoma*).tw. (0)
192 (basal gangli* adj5 hematoma*).tw. (20)
193 (basal gangli* adj5 bleed*).tw. (7)
194 (subarachnoid adj5 haemorrhage*).tw. (388)
195 (subarachnoid adj5 hemorrhage*).tw. (2120)
196 (subarachnoid adj5 haematoma*).tw. (10)
197 (subarachnoid adj5 hematoma*).tw. (68)
198 (subarachnoid adj5 bleed*).tw. (53)
199 (putaminal adj5 haemorrhage*).tw. (5)
200 (putaminal adj5 hemorrhage*).tw. (22)
201 (putaminal adj5 haematoma*).tw. (0)
202 (putaminal adj5 hematoma*).tw. (2)
203 (putaminal adj5 bleed*).tw. (0)
204 (putamen adj5 haemorrhage*).tw. (3)
205 (putamen adj5 hemorrhage*).tw. (7)
206 (putamen adj5 haematoma*).tw. (1)
207 (putamen adj5 hematoma*).tw. (2)
208 (putamen adj5 bleed*).tw. (1)
209 (posterior fossa adj5 haemorrhage*).tw. (6)

210 (posterior fossa adj5 hemorrhage*).tw. (14)
211 (posterior fossa adj5 haematoma*).tw. (5)
212 (posterior fossa adj5 hematoma*).tw. (19)
213 (posterior fossa adj5 bleed*).tw. (6)
214 (brain adj5 aneurysm*).tw. (133)
215 (cerebral adj5 aneurysm*).tw. (1231)
216 (intracranial adj5 aneurysm*).tw. (1408)
217 (communicating adj5 aneurysm*).tw. (329)
218 (giant adj5 aneurysm*).tw. (636)
219 (basilar adj5 aneurysm*).tw. (220)
220 (vertebral artery adj5 aneurysm*).tw. (112)
221 (berry adj5 aneurysm*).tw. (17)
222 (saccular adj5 aneurysm*).tw. (346)
223 (ruptured adj5 aneurysm*).tw. (1313)
224 vertebral artery dissection.tw. (116)
225 cerebral art* disease*.tw. (11)
226 (brain adj5 (vascular adj5 disease*)).tw. (63)
227 (intracranial adj5 (vascular adj5 disease*)).tw. (18)
228 (basal ganglia adj5 (vascular adj5 disease*)).tw. (0)
229 (lenticulostriate adj5 (vascular adj5 disease*)).tw. (0)
230 (brain adj5 (vascular adj5 disorder)).tw. (5)
231 (intracranial adj5 (vascular adj5 disorder)).tw. (2)
232 (basal ganglia adj5 (vascular adj5 disorder)).tw. (0)
233 (lenticulostriate adj5 (vascular adj5 disorder)).tw. (0)
234 (brain adj5 (vascular adj5 accident)).tw. (5)
235 (intracranial adj5 (vascular adj5 accident)).tw. (0)
236 (basal ganglia adj5 (vascular adj5 accident)).tw. (0)
237 (lenticulostriate adj5 (vascular adj5 accident)).tw. (0)
238 (brain adj5 (vascular adj5 injur*)).tw. (63)
239 (intracranial adj5 (vascular adj5 injur*)).tw. (7)
240 (basal ganglia adj5 (vascular adj5 injur*)).tw. (0)
241 (lenticulostriate adj5 (vascular adj5 injur*)).tw. (0)
242 (brain adj5 (vascular adj5 trauma*)).tw. (20)
243 (intracranial adj5 (vascular adj5 trauma*)).tw. (3)
244 (basal ganglia adj5 (vascular adj5 trauma*)).tw. (0)
245 (lenticulostriate adj5 (vascular adj5 trauma*)).tw. (0)
246 (brain adj5 (vascular adj5 insult)).tw. (0)
247 (intracranial adj5 (vascular adj5 insult)).tw. (0)
248 (basal ganglia adj5 (vascular adj5 insult)).tw. (0)
249 (lenticulostriate adj5 (vascular adj5 insult)).tw. (0)
250 (brain adj5 (vascular adj5 event)).tw. (2)
251 (intracranial adj5 (vascular adj5 event)).tw. (0)
252 (basal ganglia adj5 (vascular adj5 event)).tw. (0)
253 (lenticulostriate adj5 (vascular adj5 event)).tw. (0)
254 (isch?emic adj5 event).tw. (271)
255 (isch?emic adj5 events).tw. (877)

256 (isch?emic adj5 insult).tw. (241)
257 (isch?emic adj5 attack*).tw. (1404)
258 (apoplectic adj5 event).tw. (4)
259 (apoplectic adj5 events).tw. (0)
260 (apoplectic adj5 insult).tw. (0)
261 (apoplectic adj5 attack*).tw. (0)
262 (cerebral vein adj5 thrombo*).tw. (37)
263 (cerebral venous adj5 thrombo*).tw. (446)
264 (sinus adj5 thrombo*).tw. (667)
265 (sagittal adj5 thrombo*).tw. (67)
266 CVDST.tw. (0)
267 CVT.tw. (287)
268 (intracranial adj5 stenosis).tw. (241)
269 (intracranial adj5 isch?emia).tw. (34)
270 (intracranial adj5 insufficiency).tw. (5)
271 (intracranial adj5 arteriosclero*).tw. (3)
272 (intracranial adj5 atherosclero*).tw. (184)
273 (intracranial adj5 occlus*).tw. (206)
274 (cerebral art* adj5 stenosis).tw. (104)
275 (cerebral art* adj5 isch?emia).tw. (96)
276 (cerebral art* adj5 insufficiency).tw. (4)
277 (cerebral art* adj5 arteriosclero*).tw. (6)
278 (cerebral art* adj5 atherosclero*).tw. (26)
279 (cerebral art* adj5 occlus*).tw. (1415)
280 (basilar art* adj5 stenosis).tw. (28)
281 (basilar art* adj5 isch?emia).tw. (3)
282 (basilar art* adj5 insufficiency).tw. (1)
283 (basilar art* adj5 arteriosclero*).tw. (0)
284 (basilar art* adj5 atherosclero*).tw. (11)
285 (basilar art* adj5 occlus*).tw. (96)
286 (vertebral art* adj5 stenosis).tw. (68)
287 (vertebral art* adj5 isch?emia).tw. (9)
288 (vertebral art* adj5 insufficiency).tw. (8)
289 (vertebral art* adj5 arteriosclero*).tw. (0)
290 (vertebral art* adj5 atherosclero*).tw. (13)
291 (vertebral art* adj5 occlus*).tw. (110)
292 (vertebrobasilar adj5 stenosis).tw. (17)
293 (vertebrobasilar adj5 isch?emia).tw. (26)
294 (vertebrobasilar adj5 insufficiency).tw. (59)
295 (vertebrobasilar adj5 arteriosclero*).tw. (1)
296 (vertebrobasilar adj5 atherosclero*).tw. (14)
297 (vertebrobasilar adj5 occlus*).tw. (28)
298 (vertebral basilar adj5 stenosis).tw. (1)
299 (vertebral basilar adj5 isch?emia).tw. (1)
300 (vertebral basilar adj5 insufficiency).tw. (2)
301 (vertebral basilar adj5 arteriosclero*).tw. (0)

302 (vertebral basilar adj5 atherosclero*).tw. (0)
303 (vertebral basilar adj5 occlus*).tw. (1)
304 (venous adj5 malformation*).tw. (381)
305 (arteriovenous adj5 malformation*).tw. (1489)
306 (brain vasc* adj5 malformation*).tw. (3)
307 (brain adj5 angioma*).tw. (18)
308 (brain adj5 hemangioma*).tw. (12)
309 (brain adj5 haemangioma*).tw. (3)
310 (cerebral adj5 angioma*).tw. (20)
311 (cerebral adj5 hemangioma*).tw. (5)
312 (cerebral adj5 haemangioma*).tw. (7)
313 carotid*.tw. (9039)
314 patent foramen ovale.tw. (565)
315 PFO.tw. (418)
316 asymptomatic cervical bruit.tw. (0)
317 aphasi*.tw. (1554)
318 apraxi*.tw. (373)
319 dysphasi*.tw. (118)
320 dysarthri*.tw. (673)
321 hemipleg*.tw. (1178)
322 hemipar*.tw. (1374)
323 paresis.tw. (792)
324 paretic.tw. (344)
325 hemianop*.tw. (325)
326 hemineglect.tw. (40)
327 spasticity.tw. (1248)
328 anomi*.tw. (140)
329 dysnomi*.tw. (8)
330 acquired brain injur*.tw. (275)
331 hemiball*.tw. (68)
332 (unilateral adj5 neglect).tw. (111)
333 (visual adj5 neglect).tw. (80)
334 (hemispatial adj5 neglect).tw. (51)
335 (attentional adj5 neglect).tw. (14)
336 (spatial adj5 neglect).tw. (165)
337 [Dysphagia Strategy] (0)
338 deglut*.mp. (461)
339 swallow*.mp. (3354)
340 dysphag*.mp. (3459)
341 VSS.mp. (279)
342 VFSS.mp. (118)
343 FEES.mp. (835)
344 FEEST.mp. (0)
345 [Screening Strategy] (0)
346 screen*.tw,kf. (85057)
347 assess*.tw,kf. (331671)

348 (early adj2 identification).tw. (2064)
349 (early adj2 identify).tw. (448)
350 (earlier adj2 identification).tw. (110)
351 (earlier adj2 identify).tw. (28)
352 (early adj2 evaluat*).tw. (923)
353 (earlier adj2 evaluat*).tw. (74)
354 (early adj2 examine).tw. (90)
355 (early adj2 examinat*).tw. (155)
356 (earlier adj2 examine).tw. (6)
357 (earlier adj2 examinat*).tw. (27)
358 (early adj2 detect*).tw. (9576)
359 (earlier adj2 detect*).tw. (605)
360 (early adj2 diagnos*).tw. (12392)
361 (earlier adj2 diagnos*).tw. (807)
362 (advanced adj2 detection).tw. (105)
363 (advance adj2 detect*).tw. (17)
364 (early adj2 investigat*).tw. (641)
365 (earlier adj2 investigat*).tw. (196)
366 (nursing adj2 test*).tw. (34)
367 (water adj2 swallow*).tw. (62)
368 (swallow* adj2 test*).tw. (73)
369 (liquid adj2 swallow*).tw. (25)
370 [combined sets] (0)
371 or/2-336 (63178)
372 or/338-344 (7037)
373 or/346-369 (416252)
374 371 and 372 and 373 (249)
375 remove duplicates from 374 (248)

List of Excluded Articles

The following articles (n=125) were eliminated following full review and data extraction, based on the criteria: no comparison between two or more groups with and without screening assessment by a non-SLP.

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Table S1. Characteristics and outcomes of included articles.

Author, Year, **Country**	**Study Design/Data** **Source**	**N**	**Age,** mean(SD) **Male,** n(%)	**Stroke Type,** n(%) **Severity,** median(range)	**Group 1: Control** **Details**	**n(%)**	**Group 2: Experimental** **Details**	**n(%)**	**Screen Adherence, n(%)**	**Positive Screen,** n(%)	**Health and Related Outcomes*, n(%)**
A. No Screening versus Screening											
Abilleira et al., 2012, Spain[24]	Cohort; prospective stroke registry†	1697‡	75.1(12.0) 887(52.3)	**Ischemic:** 1527(89.9) **Hemorrhagic:** 170(10.1) **NIHSS‡,** n(%) ≤7: 386(61.4) 8-14: 117(18.6) >14: 126(20.0)	No screening	889 (52.4)	Screening§ (not specified)	808 (47.6)	N/A	NR	**Mortality (30-Day)** OR = 1.63(1.03-2.58) ** **Mortality (12-Month)**** OR = 1.23(0.88-1.71)
Gonzalez-Suarez et al., 2018, Philippines [28]	Cohort; retrospective chart review	1683	NR	**Ischemic** 1328(78.9) **Hemorrhagic** 319(18.9) **Other** 36(2.1) NR	No screening within 24 hours	1149 (68.3)	Screening within 24 hours (not specified)	534 (31.7)	N/A	NR	**Pneumonia** OR = 1.8(1.1-3.2)††
Joundi et al., 2019, Canada[31]	Cohort; prospective stroke registry‡‡	38192	<80 years: 23999(62.8) ≥80years: 14193(37.2) 19668(51.5)	**Ischemic** 32191(84.3) **Hemorrhagic** 6001(15.7) **CNS** ≤4: 6111(16.0) ≤7: 7824(20.5) >7: 22155(58.0)	No screening	2980	Screening (informal bedside testing or formal screening such as TOR-BSST©)	25212	N/A	NR	**Dependency§§** Group 1: 276(9.3) Group 2: 1575(6.3) OR = 3.46(3.0-3.99)

* Capture within hospital stay unless otherwise reported
† Second Stroke Audit 2007, with data from the Mortality Register of Catalonia 2007 and 2008
‡ Sample only included those who survived beyond 72 hours
§ Screening was 1 of 13 stroke guideline quality indicators that were implemented.
** Increased odds of reaching death for patients without screening; adjusted by age, sex, diabetes, dyslipidemia, hypertension, previous stroke, speech disturbance. See paper for more details.
†† Increased odds when swallow screen not provided within 24 hours of admission
‡‡ Ontario Stroke Registry
§§ Enteral feeding dependency

Author, Year, Country	**Study Design/Data Source**	**N**	**Age,** mean(SD) **Male,** n(%)	**Stroke Type,** n(%) **Severity,** median(range)	**Group 1: Control** **Details**	**n(%)**	**Group 2: Experimental** **Details**	**n(%)**	**Screen Adherence, n(%)**	**Positive Screen,** n(%)	**Health and Related Outcomes*, n(%)**
Munoz Venturelli et al., 2019, Australia[12]	Cluster crossover trial (secondary analysis)	9485***	69 years (59-79) 5759(60.7)	**Ischemic:** 9485(100.0) **NIHSS** 4(2-8)	No screening	2104 (25.1)	Screening (ASSIST[53])	6279 (74.9)	NR	NR	**Dependency or Mortality (90-Day) (mRS ≥3)†††** Group 1: 908(43.2) Group 2: 2363(37.6) OR = 1.26(1.08-1.47)‡‡‡ **Mortality (90-Day)** Group 1: 249(11.8) Group 2: 403(6.4) OR = 1.94(1.55-2.42)§§§
Ouyang et el., 2019, Australia[13]	Cluster crossover trial (secondary analysis)	11093	68 years(NR) **** 6664(60.1) ****	**Ischemic††††** 7464(85.2) **Hemorrhagic** 703(8.0) **Unclear** 592(6.8) **NIHSS** Pass Screen: 4(2-6) Fail Screen: 11(6-18)	No screening	2309 (20.8)	Screening (ASSIST[53])	8784 (79.2)	NR	2004 (22.8)	**Pneumonia** OR = 1.20(0.82-1.75)‡‡‡‡ **Dependency or Mortality (90-Day)** OR = 0.96(0.81-1.13)§§§§
Phan et al., 2019, Australia[36]	Cohort; retrospective chart review	617	69 years (16.2) 339(55.0)	**Ischemic** 436(70.7) **Hemorrhagic** 92(14.9)	No screening	137 (22.2)	Screening (ASSIST[50])	480 (77.8)	N/A	333 (69.4)	**Pneumonia** All Patients: 41(6.6) Group 1: 2(1.5) Group 2: 39(8.1)

*** Only ischemic patients of the HEADPOST sample
††† Dependency data only available data for 8383 patients; mortality data available for 9271
‡‡‡ Increased odds of good outcome (mRS 0-2) in those screened; adjusted for country, prestroke mRS, age, sex, baseline NIHSS, history of stroke, heart disease, diabetes, hypertension, time from onset to intervention, # of patients with stroke admitted annually, availability of multidisciplinary team, hospital status, use of pathway or service organization for stroke care, and availability of endovascular care.
§§§ Increased odds of mortality in those not screened; with same adjustments as pneumonia OR analysis
**** From original source (Anderson et al., 2017)
†††† Data only available for 8759 of the screened patients
‡‡‡‡ Increased odds for those screened versus not screened. Adjusted odds ratio for number of stroke patients admitted annually, academic hospital, hospital location, local protocol for dysphagia, availability of neurologists, dysphagia specialist nurses and speech pathologists
§§§§ Decreased odds for those screened versus not screened. Adjusted odds ratio for number of stroke patients admitted annually, academic hospital, hospital location, local protocol for dysphagia, availability of neurologists, dysphagia specialist nurses and speech pathologists, dedicated stroke unit, and guidelines for acute treatment of stroke care

Author, Year, Country	Study Design/Data Source	N	Age, mean(SD) Male, n(%)	Stroke Type, n(%) Severity, median(range)	Group 1: Control Details	Group 1: Control n(%)	Group 2: Experimental Details	Group 2: Experimental n(%)	Group 2: Experimental Screen Adherence, n(%)	Positive Screen, n(%)	Health and Related Outcomes*, n(%)
				Other[*****] 89(14.4) **NIHSS** (mean, SD) 8.1(7.9)							*p=NR*
Rather et al., 2010, USA[43]	Cohort; retrospective chart review	172	Group 1: 68 years (25-100) Group 2: 69 years (28-90) 82(47.8)	**Ischemic** 172(100.0) NR	No screening	86	Screening (site-specific screen)	86	NR	NR	**Pneumonia** Group 1: 5(5.8) Group 2: 0(0.0) *p=0.023* **Length of Hospital Stay** (mean, SD) Group 1: 4.91 days(3.7) Group 2: 4.56 days(5.7)
Svendsen et al., 2009, Denmark[20]	Cohort; Prospective stroke registry[†††††]	2636	≤65: 772(29.3) 66-80: 1188(45.1) >80: 676(25.6) 1432(54.3)	**Ischemic** 1769(67.1) **Hemorrhagic** 295(11.2) **Unspecified** 382(14.5)	No screening	289 (11.1) [‡‡‡‡‡]	Screening (not specified)	1168 (44.3)	N/A	NR	**Length of Hospital Stay** OR = 0.78(0.69-0.87)[§§§§§]
Teuschl et al., 2018, Austria[38]	Cohort; prospective stroke registry[******]	1394	**Group 1:** 72 years (59-82) 209(52.1) **Group 2:**	**Ischemic**[††††††] 1224(87.8) **Hemorrhagic** 169(12.1) **NIHSS**[‡]	No screening[‡‡‡‡‡‡]	401 (28.8)	Screening (GUSS[§§§§§§51] at admission[*******])	993 (71.2)	N/A	NR	**Pneumonia** All patients: 102(7.3) Group 1: 29(7.2) Group 2: 73(7.4) *p=NS*

[*****] TIA or minor stroke pathway
[†††††] Danish National Indicator Project and Danish National Registry of Patients
[‡‡‡‡‡] Study identified swallow screen to be not relevant/contraindicated in 985 patients (40.3)
[§§§§§] Decreased odds for longer hospital stay; adjusted for age, gender, marital status, housing, profession, alcohol intake, smoking habits, mRS score, atrial fibrillation, hypertension, hyperlipidemia, Charlson Comorbidity Index, Scandinavian Stroke Scale score, type of stroke, transfer to rehab ward and year of hospitalization
[******] Austrian Stroke Unit Registry
[††††††] Missing data on stroke type for 1 patient
[‡‡‡‡‡‡] Screening not administered because tracheostomy in situ, decreased consciousness, and remaining patients were screened for dysphagia with unspecified water test
[§§§§§§] Included patients suspected to have impairment of cranial nerves
[*******] Within 24 hours or 7 days

Author, Year, **Country**	**Study Design/Data** **Source**	**N**	**Age,** mean(SD) **Male,** n(%)	**Stroke Type,** n(%) **Severity,** median(range)	**Group 1: Control** **Details**	**n(%)**	**Group 2: Experimental** **Details**	**n(%)**	**Screen Adherence, n(%)**	**Positive Screen,** n(%)	**Health and Related Outcomes*, n(%)**
			77 years (67-84)[§§] 514(51.8)	Group 1: 4(1-16) Group 2: 6(3-12)							**Pneumonia ≤ 7 days** All patients: 72(5.2) Group 1: 22(5.5) Group 2: 50(5.0) *p=NS* **Pneumonia > 7 days** All patients: 30(2.2) Group 1: 7(1.7) Group 2: 23(2.3) *p=NS* **Mortality** All patients: 52(3.7) Group 1: 37(9.2) Group 2: 15(1.5) *p=<0.001*
B. Late Screening versus Early Screening											
Al-Khaled et al., 2016, Germany[3]	Cohort; prospective stroke registry[†††††††]	9164	73 years(13.0) 6569(51.4)	**Ischemic** 12781(100.0) **NIHSS**[‡] 4(2-9)	Group 1: Screening >72h	137 (1.5)	Group 2: Screen 24-72h Group 3: Screen 3-24h Group 4: Screen <3h (not specified)	431 (4.7) 3574 (39.0) 5040 (55.0)	N/A	NR	**Pneumonia** All patients: 1271(10.2) Group 1: 41(29.9) Group 2: 73(17.0) Group 3: 472(13.2) Group 4: 529(10.5) OR=0.68 (0.52-0.89)[‡‡‡‡‡‡] **Dependency at Discharge** OR=0.60(0.46-0.77) **Dependency (90-Day)** OR = 0.78(0.51-1.2)

[†††††††] Quality of Treatment of Stroke in the Federal State Schleswig-Holstein
[‡‡‡‡‡‡] Odds of pneumonia and odds of Dependency at discharge for those screened for dysphagia ≤24 hours

Author, Year, Country	**Study Design/Data Source**	**N**	**Age,** mean(SD) **Male,** n(%)	**Stroke Type,** n(%) **Severity,** median(range)	**Group 1: Control** **Details**	**n(%)**	**Group 2: Experimental** **Details**	**n(%)**	**Screen Adherence, n(%)**	**Positive Screen,** n(%)	**Health and Related Outcomes*, n(%)**
Bray et al., 2017, England[26]	Cohort; prospective stroke registry§§§§§§§	63650	77 years§§ (67-85) 31596 (49.6)	**Ischemic** 56,167(88.2) **Hemorrhagic** 6575(10.3) **Undetermined** 908(1.4) **NIHSS**‡ 4(2-9)	No screening	7812 (12.3)	Group 2: Screening at any time Group 3: Screen 0-79 min Group 4: Screen 0-176 min Group 5: Screen 177-344 min Group 6: Screen >345 min	55838 ******** (87.7) NR NR NR NR	N/A	NR ††††††††	**Pneumonia ≤ 7 days** All patients: 5533(8.7) Group 1: 1077(13.8) Group 2: 4456(8.0) *p=NR* OR = 1.36(1.20-1.53)‡‡‡‡‡‡‡‡ **Mortality (30-Day)** All patients: 8397(13.2) Group 1: 2701(34.6) Group 2: 5696(10.2) *p=NR*
Han et al., 2018, England[29]	Cohort; prospective stroke registry§§§§§§§§	3309	**Male:** 1656(50.0) 73.1 years (13.2) **Female:** 1653(50.0) 79.3 years (13.0)	**Ischemic** 2758(83.3) **Hemorrhagic** 518(15.7) **NIHSS**‡**,** n(%) NIHSS: 0 444(134) NIHSS: 1-4 1263(38.2) NIHSS: 5-15 1120(33.8) NIHSS: 16-20 255(7.7)	Screening********* >72h	142 (4.3)	Group 2: Screen 4-72h Group 3: Screen ≤4h of admission (not specified)	520 (15.7) 2647 (80.0)	N/A	NR	**Pneumonia**††††††††† All patients: 358 (11.3) Group 1: 34(23.8); OR = 2.29(1.44-3.63)‡‡‡‡‡‡‡‡‡ Group 2: 71(13.6) OR = 1.42(1.05-1.92)§§§§§§§§§ Group 3: 267(10.1) **Length of Hospital Stay (>3 weeks)** All patients: 674(23.8)**********

§§§§§§§ Sentinel Stroke National Audit Programme
******** Proportions not provided by time
†††††††† Positive screen included failed screen result and suspicion of dysphagia
‡‡‡‡‡‡‡‡ Adjusted for age, sex, stroke type, prestroke functional level, place of stroke or comorbidity, and measure of stroke severity scores (NIHSS); odds for pneumonia in those screened >345 minutes(5.75 hours); referent group = screened 0-79 minutes
§§§§§§§§ Sentinel Stroke National Audit Programme
********* Screening procedure provided, stating same validated tool provided to all patients, but tool not specified
††††††††† Data not available for pneumonia in 129 patients
‡‡‡‡‡‡‡‡‡ Increased odds of health outcomes for those screened >72h: referent group of swallow screening ≤4h of admission; adjusted for age, stroke severity, type of stroke and co-morbidities
§§§§§§§§§ Odds of pneumonia for those screened 472h; referent group <4h; adjusted for age, stroke severity, type of stroke and co-morbidities
********** Data not available in 135 patients

Author, Year, Country	Study Design/Data Source	N	Age, mean(SD) Male, n(%)	Stroke Type, n(%) Severity, median(range)	Group 1: Control Details	n(%)	Group 2: Experimental Details	n(%)	Screen Adherence, n(%)	Positive Screen, n(%)	Health and Related Outcomes*, n(%)
				NIHSS: 21-42 227(6.9)							Group 1: 1337(41.7); OR = 1.74(1.01-3.01) Group 2: 901(28.1); OR = 1.10(0.86-1.41) Group 3: 766(23.9) **Mortality** All patients: 480(15.1) Group 1: 58(40.8); OR = 3.75(2.51-5.58) Group 2: 74(14.2); OR = 1.04(0.77-1.49) Group 3: 347(13.1) **Dependency on Discharge (Mod Severe to Severe)** All patients: 509(16.1) Group 1: 78(54.9); OR = 2.52(1.73-3.68) Group 2: 181(34.8); OR = 1.35(1.09-1.68) Group 3: 731(27.6)
Middleton et al., 2019a, Australia [16] ††††††††††	Prospective cluster randomized control trial	1126 ‡‡‡‡‡‡‡‡‡	Age: n(%) <65 years: 332(29.5) 65-84 years: 619(55.0) ≥85 years: 172(15.2)	**Ischemic** 830(73.7) **Hemorrhagic** 51(4.5) §§§§§§§§§§ **Stroke Severity** ********** Mild:465(41.7)	No screening	500 (44.4)	Screening with ASSIST[53] Group 2: Screen in emergency department Group 3: Screen in emergency	626 (55.6)	242(46.0)	NR	**Dependency or Mortality (90-Day) (mRS≥2)†††††††††††:** Group 1: 358(48.0) Group 2: 111(51.0) OR = 1.08(0.79-1.48)‡‡‡‡‡‡‡‡‡‡ Group 3: 179(44.0) OR = 1.14(0.84-1.55)

††††††††† Same as parent study Middleton et al., 2011
‡‡‡‡‡‡‡‡‡ Of 6564, process of selection was unclear
§§§§§§§§§ Stroke type determined by Oxfordshire Stroke Classification Project; data only available for 881 patients
********** Stroke severity determined by Los Angeles Motor Scale; data available for 1115 patients; denominators were 451 and 558 respectively, n(%) provided
†††††††††† Available for 469 patients
‡‡‡‡‡‡‡‡‡‡ Increased odds of independence in experimental groups

Author, Year, Country	Study Design/Data Source	N	Age, mean(SD) Male, n(%)	Stroke Type, n(%) Severity, median(range)	Group 1: Control Details	n(%)	Group 2: Experimental Details	n(%)	Screen Adherence, n(%)	Positive Screen, n(%)	Health and Related Outcomes*, n(%)
			674(59.9)	More Severe: 650(58.3)			dept or ≤ 24h of stroke unit adm Group 4: Screen or assessment ≤ 24h of stroke unit adm				Group 4: 422(90.0) OR = 1.81(1.29-2.55)
Svendsen et al., 2014, Denmark[21]	Cohort; prospective stroke registry §§§§§§§§§§	5909	Age: NR********** 3229(54.6)	**Ischemic** 4749(80.4) **Hemorrhagic** 682(11.5) **Unspecified** 478(8.1) **Stroke Severity** ††††††††††, n(%) Mild: 2787(47.2) Moderate: 1181(20.0) Severe: 1104(18.7)	No screening	812 (13.7)	Group 2: GUSS[54] >24h Group 3: GUSS[54] ≤ 24h	1748 (34.3) 3237 (63.5)	N/A	NR	**Length of Hospital Stay** All patients: 20.9 days (29.5) Group 1 and 2: 26.5 days(32.0) Group 3: 18.2 days(27.5) *p=NR*
C. Informal Screening versus Formal Screening											
Hinchey et al., 2005, USA[30]	Cohort; prospective stroke registry ‡‡‡‡‡‡‡‡‡‡‡	2532	70.5 years (14) 1262(50.0)	**Ischemic:** 2532(100.0) **NIHSS**‡ 7.2(6.8-7.5)	Informal screening protocol at 6 sites	1790 (70.7)	Formal screening protocol at 6 sites	742 (29.3)	579(78.0)	NR	**Pneumonia**§§§§§§§§§§§ All patients: 104(4.1) Group 1: 95(5.3) Group 2: 18(2.4) *p=0.0016* **Mortality** All patients: 152(6.0)

§§§§§§§§§§ Danish Stroke Registry, Danish National Registry of Patients, and the Danish Civil Registration System
********** Reported only by stratified groupings by proportion of all processes received
†††††††††† Scandinavian Stroke Scale Score: Mild=45-58; Moderate=30-44; Severe=0-29; Missing data for 796 patients (13.5)
‡‡‡‡‡‡‡‡‡‡‡ Stroke Practice Improvement Network Registry
§§§§§§§§§§§ Missing data on 202 patients

Author, Year, **Country**	**Study Design/Data Source**	**N**	**Age,** mean(SD) **Male,** n(%)	**Stroke Type,** n(%) **Severity,** median(range)	**Group 1: Control** **Details**	**n(%)**	**Group 2: Experimental** **Details**	**n(%)**	**Screen Adherence, n(%)**	**Positive Screen,** n(%)	**Health and Related Outcomes*, n(%)**
											Group 1: 125(7.0) Group 2: 30(4.0) *p=0.013*
Rai et al., 2016, India [41]	Prospective cluster randomized trial	162	55 years(15.7) 119(73.5)	**Ischemic:** 124(76.5) **Hemorrhagic:** 38(23.5) **NIHSS**‡ Group 1: 6(2-14) Group 2: 6(3-20)	Conventional care (no formal screen)	85 (52.5)	Swallow screen as part of stroke care pathway (not specified)	77 (47.5)	NR	NR	**Pneumonia** All patients: 18(11.1) Group 1: 13(15.3) Group 2: 5(6.5) *p=NS* OR=0.33(0.09-1.22)********** **Dependency** (mRS, median range) All patients: NR Group 1: 2(0-4) Group 2: 2(0-4) *p=NS* **Dependency (90-Day)** (mRS score ≥3) Group 1: 36(35.6) Group 2: 44(42.8) *p=NS* **Length of Hospital Stay** All patients: NR Group 1: 7 days(3-15) Group 2: 7 days (3-19) p=NS **Mortality** All patients: 5(3.1) Group 1: 4(4.7) Group 2: 1(1.3) *p=NS* **Mortality (90-Day)**

********** Odds of aspiration pneumonia or mortality at 90-day in care pathway experimental group compared to control with 95%CI

Author, Year, **Country**	**Study Design/Data Source**	**N**	**Age,** mean(SD) **Male,** n(%)	**Stroke Type,** n(%) **Severity,** median(range)	**Group 1: Control** **Details**	**n(%)**	**Group 2: Experimental** **Details**	**n(%)**	**Screen Adherence, n(%)**	**Positive Screen,** n(%)	**Health and Related Outcomes*, n(%)**
											All patients: 23(14.2) Group 1: 17(20.0) Group 2: 6(7.8) *p=0.02* OR=0.33(0.12-0.90)
D. Pre- versus Post-Screening											
Bravata et al., 2009, USA[25]	Historical control	101	**Group 1:** 64.8 years (10.8) **Group 2:** 66.6 years (11.7) 101(100.0)	**Ischemic:** 101(100.0) **NIHSS‡,** mean(SD) Group 1: 3.85(3.96) Group 2: 3.08(3.07)	Standard care	62 (61.4)	Nurse training on screening tool†††††††††††† as part of admission nursing template	39 (38.6)	33(84.6)	8(20.5)	**Pneumonia** All patients: 2((2.0) Group 1: 1(1.6) Group 2: 1(2.6) *p=NS* **Dependency at Discharge‡‡‡‡‡‡‡‡‡‡‡‡** All patients: 41(40.6) Group 1: 25(44.6) Group 2: 16(45.7) *p=NS* **Mortality** All patients: 6(5.9) Group 1: 5(8.1) Group 2: 1(2.6) *p=NS*
Kampman et al., 2015, Norway[32]	Historical control	285	**Group 1:** 75 years (20-94) §§; 110(55.3) **Group 2:**	NR	Standard care	199 (69.8)	Screening with additional education, training and increased surveillance	86 (30.2)	Group 1: 181(90.8) Group 2: 84(97.5)	Group 1: 39(23.3) §§§§§§§§§§§§ Group 2: 18(23.4)	**Mortality <u>≤</u>2 weeks of Adm** Group 1: 14(7.0) Group 2: 7(8.1)********** *p=NR*

†††††††††††† Tool consisted of 11 items: decreased consciousness, decreased orientation, inability to follow commands, severe facial weakness, inability to control saliva, weak cough, abnormal speaking, voice, poorly articulated speech, patient or family report of difficulty swallowing

‡‡‡‡‡‡‡‡‡‡‡‡ Not independent in all activities of daily living

§§§§§§§§§§§§ Denominator is 79, as patients who died within 2 weeks of admission were excluded from this analysis

********** Mortality outcome for group 2 included death within 2 weeks of admission or terminal care only

Author, Year, Country	**Study Design/Data Source**	**N**	**Age,** mean(SD) **Male,** n(%)	**Stroke Type,** n(%) **Severity,** median(range)	**Group 1: Control**		**Group 2: Experimental**			**Positive Screen,** n(%)	**Health and Related Outcomes*, n(%)**
					Details	**n(%)**	**Details**	**n(%)**	**Screen Adherence, n(%)**		
			75 years (22-92) §§; 53(61.6)								
Lopes et al., 2018, Portugal [33]	Historical control	344	71 years (59-79) 178(51.7)	**Ischemic** 344(100.0) **NIHSS** 11(6-18)	Standard care (10-mL water swallow test)	204 (59.3)	GUSS[54]	140 (40.7)	140(100.0)	NR Group 1: 103 (50.5) Group 2: 70 (50.0)	**Pneumonia** Group 1: 25(12.5) Group 2: 21(15.1) *p=NS* OR=1.40(0.66 2.97)†††††††††††† **Dependency (90-day)** Group 1: 97(47.5) Group 2: 69(40.3) *p=NS* **Length of Hospital Stay** Group 1: 15 days(9-28) Group 2: 16 days(10-27) *p=NS* **Mortality (In-Hospital)** Group 1: 16(7.8) Group 2: 11(7.9) *p=NS* **Mortality (90-Day)** Group 1: 24(11.8) Group 2: 18(12.9) *p=NS*
Middleton et al., 2019b, Australia [40]	Cluster randomized controlled	1597	Age n(%) <65 years: 432(27.0) 65-74 years: 404(25.3)	**Ischemic:** 1531(95.9) **Hemorrhagic:** 61(3.8)	Standard care	677	ASSIST[53] with training	920	Group 1: 547(81.3) §§§§§§§§§§§§§ Group 2: 748(81.5)	NR	**Dependency or Mortality** (mRS score ≥2) **(90-Day)** ********** Group 1: 266(48.7) Group 2: 400(53.5)

†††††††††††† Increased odds of getting pneumonia if in experimental group
§§§§§§§§§§§§§ Screening adherence available for 673 and 918 patients respectively
********** Denominator for control=546, 131 lost to follow-up; denominator for experimental = 748, 172 lost to follow-up, lost patients were accounted for

Author, Year, **Country**	**Study Design/Data** **Source**	**N**	**Age,** mean(SD) **Male,** n(%)	**Stroke Type,** n(%) **Severity,** median(range)	**Group 1: Control** **Details**	**n(%)**	**Group 2: Experimental** **Details**	**n(%)**	**Screen Adherence, n(%)**	**Positive Screen,** n(%)	**Health and Related Outcomes*, n(%)**
	trial ‡‡‡‡‡‡‡‡‡‡‡‡‡		75-84 years: 480(30.5) ≥85 years: 281(17.6) 952(59.6)	**NIHSS** NIHSS 0-7: 1146(71.8) NIHSS 8-16: 313(19.6) NIHSS ≥17: 121(7.8)							*p=0.24* (Barthel Index ≥95)†††††††††††††† Group 1: 386(74.4) Group 2: 478(73.0) *p=0.87*
Paley et al., 2018, England[34]	Cohort; prospective stroke registry ‡‡‡‡‡‡‡‡‡‡‡‡‡‡	143578	77 years (67-85) 71494 (49.8)	**Ischemic** 126159(87.9) **Hemorrhagic** 15711(10.9) **NIHSS** §§§§§§§§§§§§§§ 4(2-10)	Standard care (<2 nurses trained in formal swallow screening per 10 beds)	NR	Increased screen capacity (≥2 nurses trained in formal swallow screening per 10 beds)	NR	NR	NR	**Mortality (30-Day)** OR = 0.87********** *p=0.004*
Palli et al., 2017, Austria [35]	Historical control	384	72.3 years(13.7) 190(49.5)	**Ischemic:** 384(100.0) **NIHSS**‡ Group 1: 3(0-22) Group 2: 3(0-23)	Standard care (GUSS[54] by SLP only)	198 (51.6)	Increased screen capacity (GUSS[54] by SLP or trained nurse for 24/7 implementation)	186 (48.4)	NR	Group 1: 81(40.9) Group 2: 63(33.9)	**Pneumonia** All patients: 30(7.8) Group 1: 23(11.6) Group 2: 7(3.8) *p=0.004* **Length of Hospital Stay** Group 1: 9 days(1-61) Group 2: 8 days(2-40) *p=0.033* **Mortality** All patients: 14(3.6) Group 1: 12(6.1) Group 2: 2(1.1) *p=0.012*

‡‡‡‡‡‡‡‡‡‡‡‡‡ Data for T3 trial post-intervention cohort, which includes triage, treatment, and transfer protocols
†††††††††††††† Available for 519 in control and 655 in experimental and reported scores indicating patients with slight dependency
‡‡‡‡‡‡‡‡‡‡‡‡‡‡ Sentinel Stroke National Audit Programme
§§§§§§§§§§§§§§ Available for 77% of population (n=110034)
********** Approximation as exact OR not provided; decreased odds for those in screening experimental group

Author, Year, Country	**Study Design/Data Source**	**N**	**Age,** mean(SD) **Male,** n(%)	**Stroke Type,** n(%) **Severity,** median(range)	**Group 1: Control**		**Group 2: Experimental**			**Positive Screen,** n(%)	**Health and Related Outcomes*, n(%)**
					Details	**n(%)**	**Details**	**n(%)**	**Screen Adherence, n(%)**		
Perry & McLaren 2000a and 2000b, England[18, 19]	Historical control	400	Group 1: 73.4 years (12.6) Group 2: 71.6 years (13.3)	**Ischemic** 352(88.0) **Hemorrhagic** 48(12.0) **NIHSS** Group 1:	Standard care	200 (50.0)	Screening administered within 24 hours (screen not specified)	200 (50.0)	Group 1: 106(57.3) Group 2: 123(74.5)	Group 1: 77(41.6) Group 2: 75(43.1)	**Infective Rates (including chest infection, aspiration pneumonia, or sepsis)** Group 1: 33(16.5) Group 2: 13(6.5) *p<0.003*
			208(52.0)	7(1-26)†††††††††††††† Group 2: 8(0-24)							**Mortality** Group 1: 47(23.5) Group 2: 57(28.5) *p=NS* **Dependency (Discharge)** (Barthel Index, median, 25th, 75th centile) Group 1: 16(11,20) Group 2: 16(10,19) *p=NS* **Length of Hospital Stay** (mean, SD) Group 1: 29.9 days(30.2) Group 2: 29.5 days(30.3) *p=NS*
Schrock et al., 2018, USA[37]	Historical control	2372	**Ischemic** Group 1: 63 years(53-76) §§ 208(50.0) Group 2: 64 years(56-76) §§ 512(50.0)	**Ischemic** (n=1441) Group 1: 419((17.7) Group 2: 1022(43.1) **NIHSS**‡ Group 1: 6(3-10)	Standard care§§§§§§§§§§§§§§§§	888 (37.4)	MetroHealth Dysphagia Screen[55] **********	1484 (62.6) Ischemic Hemorrhagic	NR	NR	**Pneumonia** All patients: 391(16.5) Group 1: 212(23.9) Group 2: 179(12.1) *p=NR* *Ischemic* Group 1: 123(13.8) Group 2: 119(8.0) *p=0.007*

†††††††††††††† NIHSS median, Stroke Severity Scale score range
§§§§§§§§§§§§§§§§ Data collected for four years before screen implementation in ischemic group, and five years before screen in hemorrhagic group
********** Data collected for four years after screen implementation in ischemic group, and five years after screen in hemorrhagic group

Author, Year,	**Study Design/Data**	**N**	**Age,** mean(SD)	**Stroke Type,** n(%)	**Group 1: Control**		**Group 2: Experimental**			**Positive Screen,**	**Health and Related Outcomes*, n(%)**
Country	**Source**		**Male,** n(%)	**Severity,** median(range)	**Details**	**n(%)**	**Details**	**n(%)**	**Screen Adherence, n(%)**	n(%)	
			Hemorrhagic Group 1: 61 years(50-75)[§§] 251(53.0) Group 2: 64 years(54-77)[§§] 215(47)	Group 2: 4(2-8) **Hemorrhagic** (n=931) Group 1: 469(19.8) Group 2: 462(19.5) **ICH score** Group 1: 2(1-3) Group 2: 1(1-3)							*Hemorrhagic* Group 1: 89(19.0) Group 2: 60(13.02.) *p=<0.001* **Mortality** All patients: 348(14.7) Group 1: 167(18.8) Group 2: 181(12.2) *p=NR* *Ischemic* Group 1: 12(3.0) Group 2: 56(5.0) *p=NS* *Hemorrhagic* Group 1: 155(33.0) Group 2: 125(27.0) *p=NS*
Yeh et al., 2011, Taiwan[39]	Cohort; Prospective stroke registry ††††††††††††††††	176	Group 1: 64.4 years (13.3) Group 2: 69.9 years(13.7) 88(50.0)	**Ischemic** 123(69.9) **Hemorrhagic** 53(30.1) **NIHSS** Group 1: 13.7(8.1) Group 2: 14.9(8.8)	Standard care	74 (42.0)	Three-Step Swallowing Screen ‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡	102 (58.0)	NR	NR	**Pneumonia** Group 1: 45(60.8) Group 2: 55(53.9) *p=0.44* OR=0.42(0.18-1.00) §§§§§§§§§§§§§§§§ **Length of Hospital Stay** Group 1: 31.9 days(25.1) Group 2: 32.4 days(28.4) *p=0.90* **Mortality (In Hospital)** Group 1: 7(9.5)

†††††††††††††††† National Taiwan University Hospital Stroke Registry
‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡ Combination of two bedside water swallowing tests[e5,e6]
§§§§§§§§§§§§§§§§ Decreased odds of both pneumonia and mortality in hospital for all patients who were screened for dysphagia vs. not screened

Author, Year, **Country**	**Study Design/Data** **Source**	**N**	**Age,** mean(SD) **Male,** n(%)	**Stroke Type,** n(%) **Severity,** median(range)	**Group 1: Control** **Details**	**n(%)**	**Group 2: Experimental** **Details**	**n(%)**	**Screen Adherence, n(%)**	**Positive Screen,** n(%)	**Health and Related Outcomes*, n(%)**
											Group 2: 11(10.8) *p=0.81* OR=0.79(0.26-2.39)
E. Pre- versus Post-Guideline with Screening											
Burgess et al., 2012, New Zealand[42]	Cohort; retrospective chart review	294	Group 1: 71.7 years (69.7-73.9) Group 2: 73.4 years (71.4-75.4) 153(52.0)	**Ischemic** 252(85.7) **Hemorrhagic** 37(12.6) NR	Standard care	139	New dedicated stroke unit with nurse training in swallow screening (not specified)	155	Group 1: 88(63.3) Group 2: 129(84.9)	NR	**Pneumonia********** Group 1: 21(15.1) Group 2: 16(10.3) *p=0.22* **Mortality (In-Hospital)** Group 1: 22(16.2) Group 2: 15(10.0) *p=0.12* **Mortality (6-Month)** Group 1: 29(21.3) Group 2: 27(18.0) *p=0.48* **Dependency (Discharge)** (Barthel Index, mean, range) Group 1: 14.4(12.9-15.9) Group 2: 16.2(15.1-17.3) *p=0.05* **Length of Hospital Stay** Group 1: 20.5 days (16.5-25.1) Group 2: 18.3 days (15.4-21.1) *p=0.34*
Di Matteo et al., 2004, New Zealand[27]	Cohort; retrospective chart review	200	Group 1: 70 years(31-89) 49(49.0)	NR	Standard care	100	Screen administered as new process of care on acute stroke unit	100	Group 1: 35(35.0) Group 2: 41(41.0)		**Mortality** *Group 1: 5(5.0)* *Group 2: 9(9.0)* *p=0.02*

********** Outcome data available for 139 and 155 patients for pneumonia, and 136 and 150 for mortality

Author, Year, Country	**Study Design/Data Source**	**N**	**Age,** mean(SD) **Male,** n(%)	**Stroke Type,** n(%) **Severity,** median(range)	**Group 1: Control**		**Group 2: Experimental**			**Positive Screen,** n(%)	**Health and Related Outcomes*, n(%)**
					Details	**n(%)**	**Details**	**n(%)**	**Screen Adherence, n(%)**		
Middleton et al., 2011, 2017; Australia[15, 17]	Prospective cluster randomized control trial	1126 ††††††††††	Group 2: 70 years (33-96) 47(47.0) Age: n(%) <65 years: 332(29.5) 65-84 years: 619(55.0) ≥85 years: 172(15.2) 674(59.9)	**Ischemic** ‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡ 830(73.7) **Hemorrhagic** 51(4.5) **Stroke Severity** §§§§§§§§§§§§§§§§ Mild:465(41.7) More Severe: 650(58.3)	Standard care	500 (44.4)	Fever, Sugar, Swallowing Protocol including ASSIST[53]	626 (55.6)	242(46.0)	NR	**Pneumonia********** Group 1: 13(3.0) Group 2: 13(2.0) *p=NS* **Length of Hospital Stay** Group 1: 13.7 days(12.7) Group 2: 11.3 days(10.3) *p=NS* **Mortality (90-Day)********* Group 1: 24(5.3) Group 2: 21(3.7) *p=NS* **Dependency or Mortality (90-Day)**†††††††††††††††† (mRS≥2) Group 1: 259 (58.0) Group 2: 236(42.0) *p=0.002* **Mortality (3-5 Years)**‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡ HR = 0.77(0.59–0.99)§§§§§§§§§§§§§§§§ *p=0.045*

†††††††††††††††† Of 6564, of which selection was unclear
‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡ Stroke type determined by Oxfordshire Stroke Classification Project; data only available for 881 patients
§§§§§§§§§§§§§§§§ Stroke severity determined by Los Angeles Motor Scale; data available for 1115 patients; denominators were 451 and 558 respectively, n(%) provided
********** Data available for 483 and 603 respectively
†††††††††††††††† Available data for 451 control patients and 558 intervention patients
‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡ Data available for 1076 patients
§§§§§§§§§§§§§§§§ Hazards ratio: Decreased risk for those in experimental group; adjusted for age, sex, marital status, education and stroke severity

Author, Year, Country	**Study Design/Data Source**	**N**	**Age,** mean(SD) **Male,** n(%)	**Stroke Type,** n(%) **Severity,** median(range)	**Group 1: Control**		**Group 2: Experimental**			**Positive Screen,** n(%)	**Health and Related Outcomes*, n(%)**
					Details	**n(%)**	**Details**	**n(%)**	**Screen Adherence, n(%)**		
Odderson et al., 1993; 1995, USA [22,23]	Historical control	335	Group 3: Dysphagia: 75.2 years (1.5) No Dysphagia: 75.3 years(1.4) 49(39.5)	**Ischemic** 124(100.0)	Standard care	90	Group 2: 1st year of pathway including screen (1991-1992) Group 3: 2nd year of pathway including screen (1993) (screen not specified)	121 124 (100.0)	Group 2: 87(71.9)	48(38.7)	**Pneumonia** Group 1: 6(6.7) Group 2: 5(4.1) Group 3: No cases *p=NR* **Length of Hospital Stay** Group 1: 10.9 days(1.2) Group 2: 7.3 days(0.5) Group 3: NR
Pinero-Saez et al., 2018, Spain[44]	Historical control	457	68.8 years(12.8) 293(64.1)	**Ischemic** 348(76.1) **Hemorrhagic** 32(7.0) **Transient Ischemic Attack** 77(16.8) **Stroke Severity:** NR	Standard care	30 (6.6)	Group 2: Two-step screening ********** 1-year post-implementation Group 3: Two-step screening 2-years post-implementation	66 (14.4) 361 (79.0)	**Group 2** Step 1: 12 (18.2) Step 2: 14(21.2) **Group 3** Step 1: 200(55.4) Step 2: 203(56.2)	NR	**Pneumonia** All patients: 6(1.3) Group 1: 1(3.3) Group 2: 0(0.0) Group 3: 5(1.4) p=NS **Length of Hospital Stay** Group 1: 5.2 days(3.57) Group 2: 5 days(3.65) Group 3: 5.75 days(5.59) p=NS

********** Step 1: screening within 24 hours of adm; Step 2: screening pre-intake – implemented as part of best practice guidelines

SD = standard deviation; OR = odds ratio; NA = not applicable; NR = not reported; CNS = Canadian Neurological Scale; TOR-BSST = Toronto Bedside Swallowing Screening Test

NIHSS = National Institutes of Health Stroke Scale; mRS = Modified Rankin Scale; ASSIST = Acute Screening of Swallow in Stroke/TIA

NS = not significant; ICH = intracerebral hemorrhage