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REVIEW ARTICLE

Prevalence, causes and risk factors of hospital readmissions after acute stroke and transient ischemic attack: a systematic review and meta-analysis

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Abstract Acute stroke and transient ischemic attack (TIA) is a great burden not only during hospitalization but also after hospital discharge. The objective of this meta-analysis was to evaluate the hospital readmissions, causes and risk factors after survival of acute stroke and TIA. Pubmed, Web of Science, Cochrane Library, OVID and EMBASE databases were searched to identify studies reporting hospital readmissions after acute stroke and TIA. The primary outcomes were hospital readmission rates during 30 days and 1 year after discharge. The primary causes and risk factors of hospital readmissions were also identified. Ten studies with 253,680 patients were eligible for inclusion. The pooled 30-day and 1-year hospital readmission rates were 17.4 % (95 % CI, 12.7–23.5 %) and 42.5 % (95 % CI, 34.1–51.3 %), respectively. The three major causes of 30-day hospital readmissions were infection (19.9 %), coronary artery disease (CAD) (17.8 %) and recurrent stroke (16.0 %) successively, while the three major causes were recurrent stroke (19.4 %), infection (19.3 %) and CAD (16.3 %) during 1 year's follow-up. There were more patients with CAD in readmits group than that in control group ($p = 0.030$). The length of index admission, defined as any eligible admission to an acute care hospital assessed in the measure for the outcome, was longer ($p = 0.000$) and admission National Institutes of Health Stroke Score (NIHSS) was higher ($p = 0.002$) in readmits group than these in control group. In conclusion, there is high risk of early and long-term hospital readmissions after survival of acute stroke and TIA. These patients with coronary artery disease, longer length of index admission and higher NIHSS deserve deep attention after hospital discharge.

Keywords Acute stroke · Transient ischemic attack · Hospital readmission · Meta-analysis

Introduction

Acute stroke and transient ischemic attack (TIA) is emerging as a leading cause of preventable death and disability worldwide [1]. Stroke survivors often face high risks of mortality and stroke recurrence. For stroke patients, hospitalizations can be stressful and even more so when they result in subsequent readmissions to the hospital. It has been found that 16 % of stroke patients may experience two or more readmissions within 30 days of the incident admission [2] and about 50 % of 30-day readmissions have been classified as avoidable [3].

Hospital readmissions contribute significantly to the cost of inpatient care and are targeted as a marker for quality of care [4]. Researchers have found wide variation in hospitals' readmission rates [5] and a number of studies show that hospitals can engage in several activities to lower their rate of readmissions [6]. In USA, Medicare has started implementing incentives to reduce hospital readmissions, such as the Hospital Readmissions Reduction Program (HRRP).

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We conducted a meta-analysis to estimate the pooled short-term and long-term readmission rates, the common causes and the risk factors of readmissions after discharge of acute stroke and TIA during various follow-up periods. This effort hopes to raise awareness of hospital readmissions after acute stroke and TIA, and to provide considerable healthcare resources after hospital discharge.

Methods

Search strategy and data sources

We performed a computerized search to identify relevant published original studies (1985 to November 2015). Pubmed, Web of Science, Cochrane Library, OVID and EMBASE databases were searched using medical subject headings (MeSH) or keywords. These words were "acute stroke, acute ischemic stroke (AIS), transient ischemic attack, acute cerebral infarction, acute intracerebral hemorrhage (ICH), acute cerebral hemorrhage, hemorrhagic stroke" and "re*hospital*, re*admission*". This search was not limited to English language or publication type.

Selection criteria

An initial eligibility screen of all retrieved titles and abstracts was conducted, and only studies reporting rehospitalization after acute stroke or TIA were selected for further review. The following included criteria were used for final selection: (1) studies reporting the hospital readmissions after AIS, TIA or ICH, (2) studies providing detailed information about the rehospitalization rates during follow-up periods (30 days or 1 year). We restricted our search to clinical studies performed in adult populations. Studies without clear rehospitalization rates or experimental studies were excluded.

Data extraction and quality assessment

WBZ performed the first screening of published reports, while two reviewers (WBZ and NG) independently examined the studies, and disagreement was resolved by discussion. Data extraction included country of origin, year of publication, study period, source of data, primary diseases, sample size, patient characteristics (age and sex). The primary outcomes were hospital readmission rates during 30 days and 1 year after discharge. The primary causes and risk factors of hospital readmissions were also identified. The study selection, data extraction, and reporting of results were all based on the preferred reporting items for systematic reviews and meta-analyses checklist [7]. The quality of the cohort studies was assessed independently by pairs of two authors, using the Newcastle–Ottawa scale (NOS) [8], which allocates a maximum of nine points for quality of the selection, comparability, and outcome of study populations. Study quality scores were defined as poor (0–3), fair (4–6), or good (7–9).

Data synthesis and statistical analysis

Comprehensive meta-analysis (version 2.0; Biostat) was used to perform the meta-analysis. Pooled estimates were obtained for rates, causes and risk factors of hospital readmissions reported using random-effects meta-analysis based on the methods of DerSimonian and Laird [9]. Meta-analyses were performed using odds ratio (OR) for dichotomous outcomes and standard difference (Std diff) in means for continuous outcomes. All confidence intervals (CI) were reported at 95 percent. *P* value statistical significance was measured at 0.05. Heterogeneity across trials was evaluated with using the I^2 index and the Q test *p* value. A *p* value of less than 0.05 and an I^2 index of more than 25 % indicated the presence of interstudy heterogeneity [10]. Publication bias was assessed by constructing a funnel plot and Egger's regression test.

Results

Study selection

The article selection process is outlined in Fig. 1. After primary screening, 116 articles were excluded without meeting criteria of final selection. At the full-text review stage, 35 articles were not about acute stroke or TIA, 18 did not involve rehospitalization and 15 were reviews. Four studies were excluded from the primary meta-analysis as they did not report the number of patients rehospitalizing during the follow-up periods, and the corresponding authors were unable to provide the requisite data. After screening, ten studies with 253,680 patients were included in this systematic review. Agreement between investigators

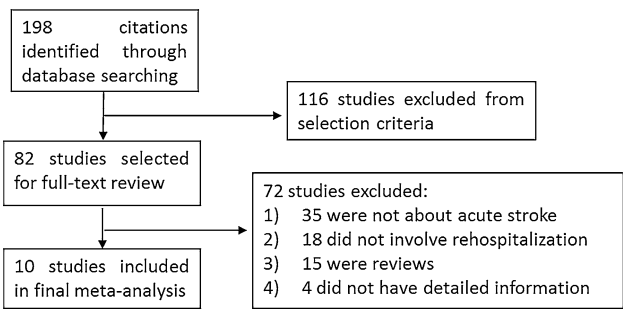

Fig. 1 Flowchart of literature search and study selection

at the full-text review stage was excellent as indicated by a κ of 0.8.

Study description and quality assessment

A detailed description of the included studies is provided in Table 1. The included studies were published between 2006 and 2015. Most of the included studies ($n = 7$) occurred in the United States of America, and two in China (Taiwan). The total number of patients included in the primary meta-analysis was 253,680 with a median (interquartile range) of 1009 (121–200,900) patients per study. Detailed information of age and gender is also listed in Table 1. Overall study quality was good with a mean NOS score of 7.6 out of a possible nine (range, 6–9) and with eight studies (80 %) receiving a NOS greater than or equal to seven Table 2.

Hospital readmission rates after acute stroke

Five studies reported 30-day post-discharge hospital readmissions after acute stroke, including AIS, TIA and ICH, and six reported 1-year rehospitalization. The pooled 30-day and 1-year hospital readmission rates were 17.4 % (95 % CI, 12.7–23.5 %) and 42.5 % (95 % CI, 34.1–51.3 %), respectively. Three studies including patients only with AIS reported 30-day and 1-year rehospitalization, and the pooled 30-day and 1-year readmission rates of these patients were 12.4 % (95 % CI, 10.8–14.1 %) and 53.0 % (95 % CI, 49.7–56.2 %), respectively (Fig. 2). There were not enough trials to conduct the readmission rates in other subgroups, such as ICH.

Causes of hospital readmissions after acute stroke

Five studies identified the causes of hospital readmissions within 30 days after discharge, while six reported the causes within 1 year's follow-up. The three major causes of 30-day hospital readmissions were infection, coronary artery disease (CAD) and recurrent stroke, and the pooled percentage of these causes was 19.9 % (95 % CI, 5.1–53.1 %), 17.8 % (95 % CI, 5.6–44.2 %) and 16.0 % (95 % CI, 8.6–27.7 %), respectively (Fig. 3). During 1 year's follow-up, the three major causes of readmissions were recurrent stroke, infection and CAD, and the pooled percentage of these causes was 19.4 % (95 % CI, 14.8–25.0 %), 19.3 % (95 % CI, 15.5–23.7 %) and 16.3 % (95 % CI, 14.8–18.1 %).

Risk factors of hospital readmissions after acute stroke

Four studies compared the risk factors of hospital readmissions with control group. There were more patients with CAD in readmits group than that in control group (OR 0.326, 95 % CI 0.119–0.897, $p = 0.030$). No significant differences were identified when comparing other risk factors such as diabetes mellitus (DM), hypertension, atrial fibrillation (AF), and in-hospital neurologic deterioration

Table 1 Characteristics of studies included in the meta-analysis

Author (year)	Study period	Country	Source of data	Primary diseases	Sample size	Mean age of patients (years)	Men (%)
Strowd et al. [11]	NR	USA	UHC reports	AIS or ICH	165	68.0	49.1
Shah et al. [12]	2012–2013	USA	Northwestern University Brain Attack Registry	AIS or TIA	505	65.6	51.9
Bjerkreim et al. [13]	2007–2012	Norway	Bergen NORSTROKE registry	ICH	121	72.3	55.4
Qian et al. [14]	2003–2008	USA	AHA-GWTG–Stroke registry	AIS	200,900	76.9	58.2
Olson et al. [15]	NR	USA	AHA/ASA-GWTG-S program from across the United States	AIS or TIA	2802	60.0	53.6
Li et al. [16]	2004–2007	China (Taiwan)	BNHI	AIS	1194	68.0	59.3
Lakshminarayan et al. [17]	2000–2005	USA	PRISMM	AIS	823	76.0	48.2
Tseng et al. [18]	2000–2001	China (Taiwan)	NHI Research Database in Taiwan	Acute stroke	468	67.0	55.5
Bravata et al. [19]	1995	USA	Fee-for-service Medicare beneficiaries	AIS	2603	80.0	60.3
Smith et al. [20]	1998–2000	USA	Medicare beneficiaries	AIS	44,099	80.0	38.5

USA United States of America, *UHC* University Health System Consortium, *NORSTROKE* Norwegian Stroke Research Registry, *AHA* American Heart Association, *ASA* American Stroke Association, *GWTG* Get With The Guidelines, *GWTG-S* Get With The Guidelines–Stroke, *BNHI* Bureau of National Health Insurance, *PRISMM* The Project for Improvement of Stroke Care Management in Minnesota, *NHI* National Health Insurance, *AIS* Acute ischemic stroke, *TIA* Transient ischemic attack, *ICH* Intracerebral hemorrhage, *NR* not reported

Table 2 Quality of the studies utilizing the Newcastle–Ottawa quality assessment scale (Cohort studies)

Reference (Year)	Selection				Comparability	Outcome			Total score
	Representativeness of exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Demonstration that outcome was not present at start of study	Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	Follow-up long enough	Adequacy of follow-up of cohorts	
Strowd et al. [11]	☆	☆	☆	☆	☆☆	☆	NA	NA	7
Shah et al. [12]	☆	☆	☆	☆	☆☆	☆	NA	NA	7
Bjerkreim et al. [13]	☆	☆	☆	☆	☆☆	☆	☆	☆	9
Qian et al. [14]	☆	☆	☆	☆	☆	☆	☆	☆	8
Olson et al. [15]	☆	☆	☆	☆	☆	☆	☆	☆	8
Li et al. [16]	☆	☆	☆	☆	☆	☆	NA	NA	6
Lakshminarayan et al. [17]	☆	☆	☆	☆	☆	☆	☆	☆	8
Tseng et al. [18]	☆	☆	☆	☆	☆☆	☆	☆	☆	9
Bravata et al. [19]	☆	☆	☆	☆	☆	☆	☆	☆	8
Smith et al. [20]	☆	☆	☆	☆	☆	☆	NA	NA	6

NA not applicable

☆ A study can be awarded a maximum of one star for each numbered item in the selection and outcome categories. A maximum of two stars can be given for comparability

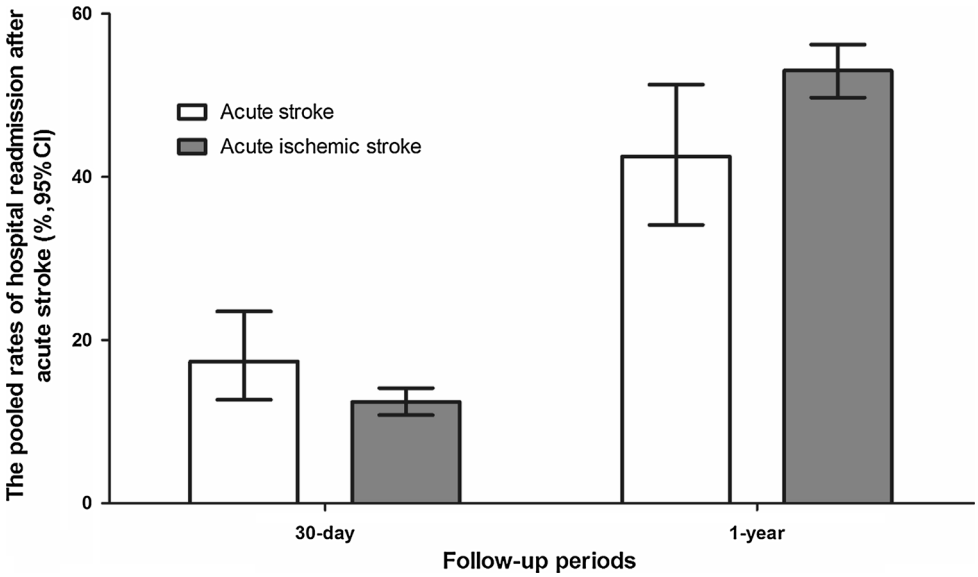

Fig. 2 The pooled hospital readmission rates after acute stroke within 30-day and 1-year follow-up

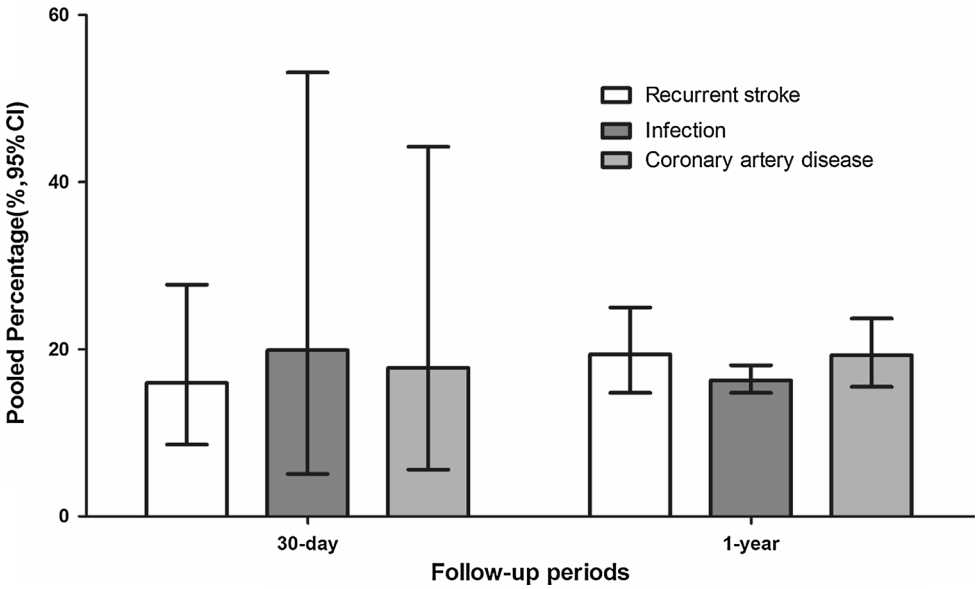

Fig. 3 Pooled estimators for three major causes of hospital readmission after acute stroke

(Fig. 4). The length of index admission, defined as any eligible admission to an acute care hospital assessed in the measure for the outcome, was longer (Std diff in means 0.254, 95 % CI 0.129–0.380, $p = 0.000$) and admission National Institutes of Health Stroke Score (NIHSS) was higher (Std diff in means 0.281, 95 % CI 0.107–0.454, $p = 0.002$) in readmits group than these in control group (Fig. 5).

Publication bias

The funnel plots for Fig. 6 showed no evidence of publication bias. Egger's test for a regression intercept gave a p value of 0.401 for 30-day rehospitalization rates after acute stroke and TIA, indicating no publication bias.

Discussion

Our meta-analysis showed that about 17.4 % of discharges after acute stroke and TIA resulted in hospital readmissions within 30 days and 42.5 % within 1 year. To our knowledge, this was the first time to conduct a meta-analysis reporting hospital readmissions after acute stroke and TIA. Given the high heterogeneity, it is best to consider the confidence interval rather than the pooled result. It is likely that the reported rates underestimate the true rate of readmissions, as patients may be treated at a different hospital and may not be reflected in the included studies. The readmission rates might be different for patients with various primary diseases, such as AIS, TIA and ICH. But we only identified enough studies to conduct the pooled

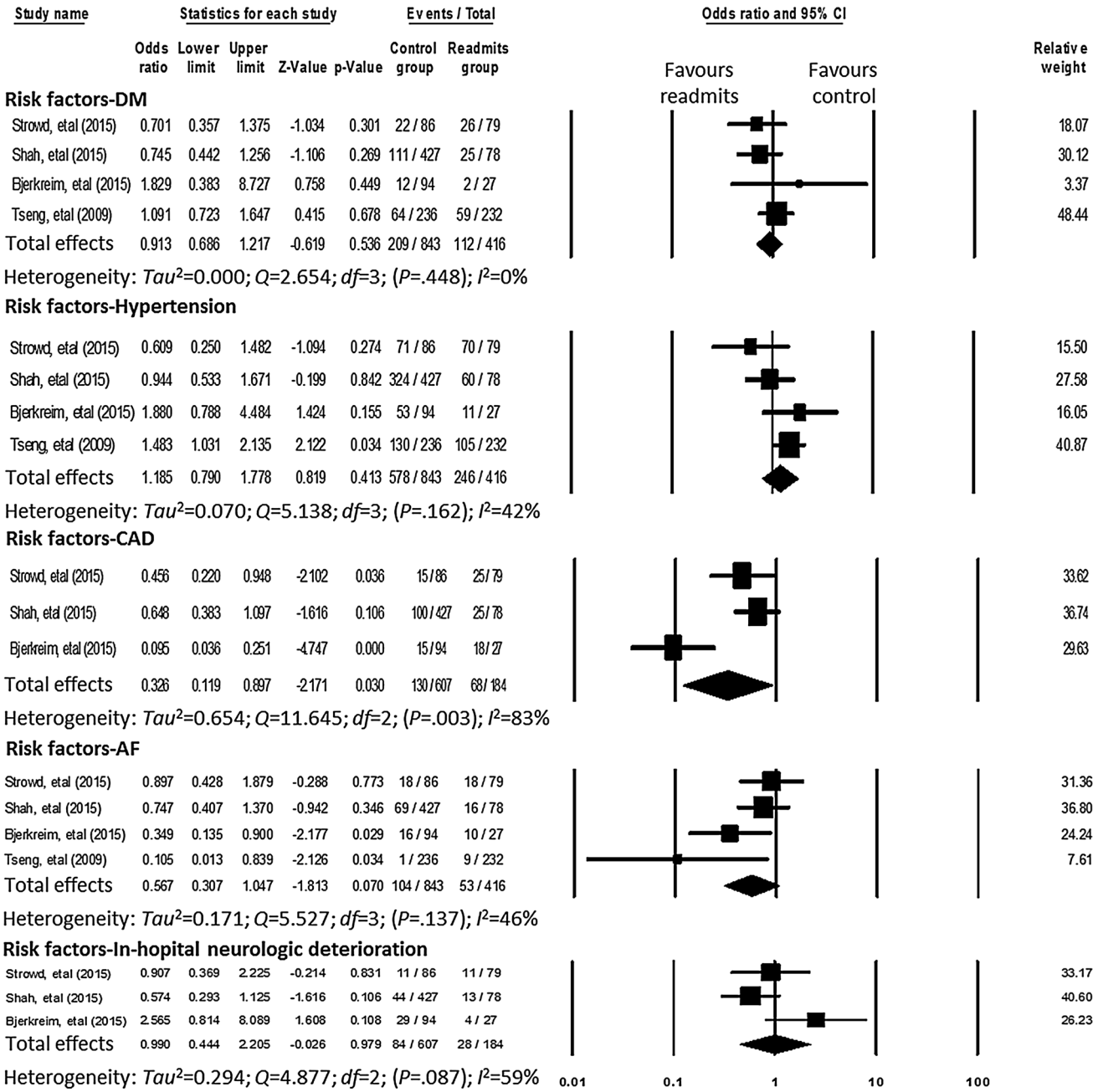

Fig. 4 Risk factors of hospital readmission after acute stroke—dichotomous variables. *DM* diabetes mellitus, *CAD* coronary artery disease, *AF* atrial fibrillation

readmission rates in patients with AIS. The readmission rates in AIS subgroup seemingly were lower within 30 days and higher within 1 year when comparing with total stroke patients. For limited data, further investigation may be needed to compare different readmission rates within various types of stroke.

This review also identified several common causes that lead to hospital readmissions after acute stroke. Infection, CAD and recurrent stroke were the three leading reasons not only within 30 days but also 1 year after discharge. The three major causes of 30-day hospital readmissions were infection, coronary artery disease (CAD) and recurrent stroke successively, while the three major causes were recurrent stroke, infection and CAD during 1 year's follow-up. Infection seemingly accounted for the more proportion of readmissions within 30 days than CAD and recurrent stroke.

Although this study highlights predictors associated with unplanned readmission, it was not possible to perform a meta-regression analysis evaluating how these risk

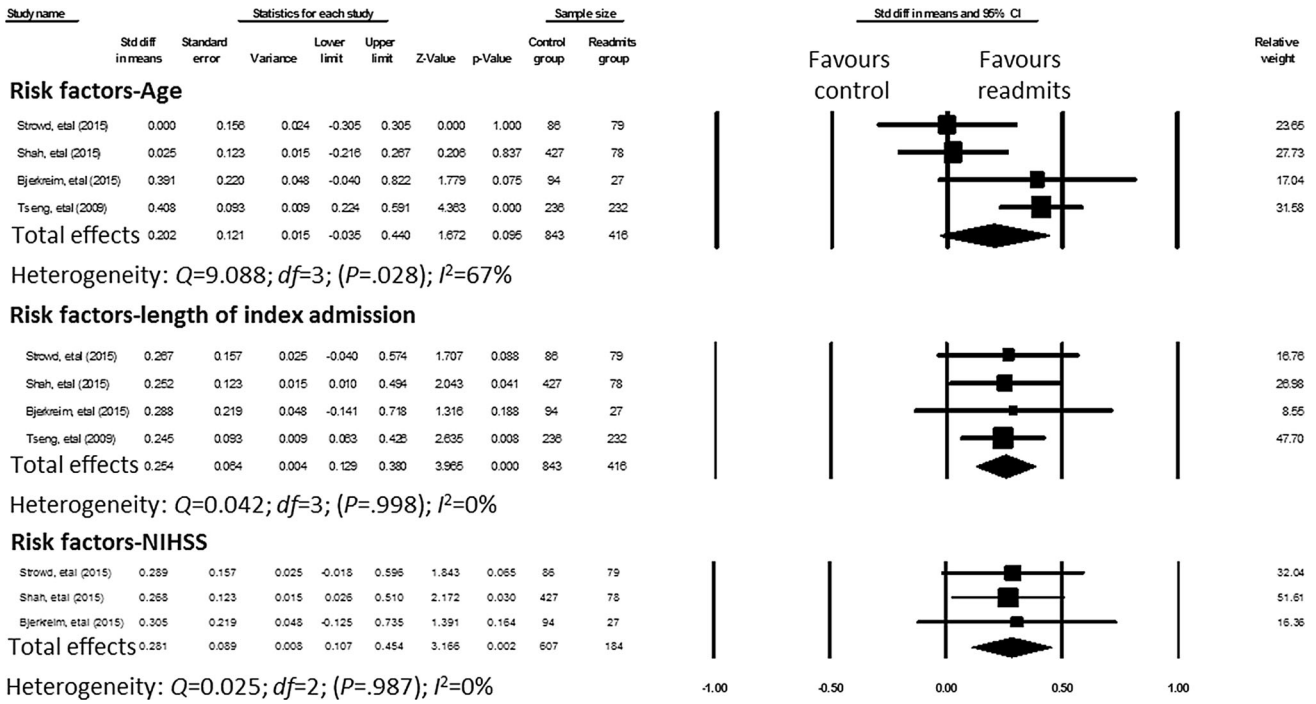

Fig. 5 Risk factors of hospital readmission after acute stroke—continuous variables

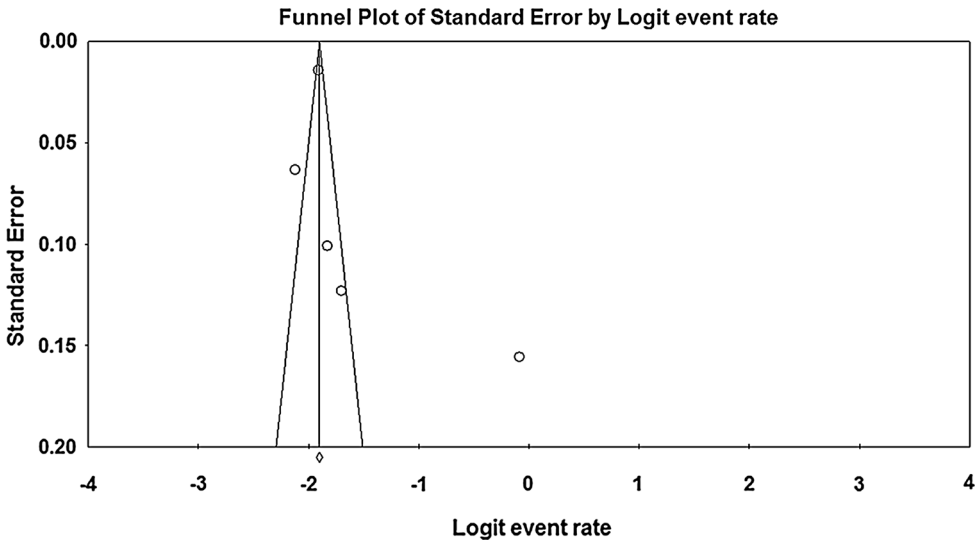

Fig. 6 Funnel plot to evaluate for publication bias for 30-day rehospitalization rates after acute stroke

factors were associated with the overall pooled estimates, because too few studies comparably collected or reported individual factors. Four included studies compared the risk factors of hospital readmissions with control group. There were more patients with CAD in readmits group than that in control group, and stroke patients with longer length of index admission and higher NIHSS were more likely to readmit within 30 days after discharge. These factors and other factors that were identified as risk factors of readmissions may be potentially modifiable targets in future studies.

Study limitations

The present study may have limitations. Firstly, significant difference across studies in primary diseases, age and the assessment of variables, such as causes and risk factors of hospital readmissions, may lead to high heterogeneity. Secondly, all publications included in this analysis were retrospective observational studies, which are considered moderate evidence, and so the conclusions drawn in this analysis are limited by this study type. Finally, for limited studies, we could not estimate the causes and risk factors in

subgroups, such as AIS and ICH, and there must be differences in these subgroups.

In conclusion, results of our systematic review suggest that there is high risk of early and long-term hospital readmissions after discharge of acute stroke and TIA. These patients with CAD and longer length of index admission and higher NIHSS deserve deep attention after hospital discharge. Further large-scale, multicenter studies with careful matching and enough follow-up periods needed for more persuasive analysis.

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Compliance with ethical standards

Conflict of interest All authors have no potential conflicts of interest for this work.

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