BMC Geriatrics

RESEARCH

Open Access

Meta-analysis and systematic review of the relationship between sex and the risk or incidence of poststroke aphasia and its types

Ting-ting Li[1†], Ping-ping Zhang[2†], Ming-chen Zhang[1†], Hui Zhang[1], Hong-ying Wang[1], Ying Yuan[1], Shan-lin Wu[1], Xiao-wen Wang[1*] and Zhong-guang Sun[1*]

Abstract

Objective To analyse and discuss the association of gender differences with the risk and incidence of poststroke aphasia (PSA) and its types, and to provide evidence-based guidance for the prevention and treatment of poststroke aphasia in clinical practice.

Data sources Embase, PubMed, Cochrane Library and Web of Science were searched from January 1, 2002, to December 1, 2023.

Study selection Including the total number of strokes, aphasia, the number of different sexes or the number of PSA corresponding to different sex.

Data extraction Studies with missing data, aphasia caused by nonstroke and noncompliance with the requirements of literature types were excluded.

Data synthesis 36 papers were included, from 19 countries. The analysis of 168,259 patients with stroke and 31,058 patients with PSA showed that the risk of PSA was 1.23 times higher in female than in male (OR = 1.23, 95% CI = 1.19–1.29, $P < 0.001$), with a prevalence of PSA of 31% in men and 36% in women, and an overall prevalence of 34% ($P < 0.001$). Analysis of the risk of the different types of aphasia in 1,048 patients with PSA showed a high risk in females for global, broca and Wenicke aphasia, and a high risk in males for anomic, conductive and transcortical aphasia, which was not statistically significant by meta-analysis. The incidence of global aphasia (males vs. females, 29% vs. 32%) and broca aphasia (17% vs 19%) were higher in females, and anomic aphasia (19% vs 14%) was higher in males, which was statistically significant ($P < 0.05$).

Conclusions There are gender differences in the incidence and types of PSA. The risk of PSA in female is higher than that in male.

Keywords Sex, stroke, Poststroke aphasia, aphasia type, incidence rate

†Ting-ting Li Ping-ping Zhang and Ming-chen Zhang contributed equally to this work.

*Correspondence:
Xiao-wen Wang
Wangxiaowen2003@126.com
Zhong-guang Sun
sunzhongguang@outlook.com
Full list of author information is available at the end of the article

Introduction

Stroke is the second leading cause of death in the world, and poststroke aphasia (PSA) is a common sequela of stroke patients [1, 2]. PSA is a speech disorder caused by the impairment of the language function area of the dominant hemisphere. The incidence of stroke is increasing year by year, from 13.34% in 2003 to 21.94% in 2014 and 29.55% in 2021 [3, 4]. The factors influencing PSA deserve exploring as an important factor predicting recovery or death after stroke [5, 6].

The severity and age of stroke can predict the risk of PSA [7, 8], and the location and size of stroke have an important reference role in predicting PSA types [9]. But whether gender plays a predictive role in the incidence of PSA and its types is still controversial [10, 11]. The lateralization of cerebral hemisphere use and the onset age of stroke affect the incidence of PSA in different sexes [12]. At present, it is considered that global aphasia and broca aphasia are the most common types of PSA. But the incidence and risk of PSA between different sexes are inevitably biased the accuracy of the conclusions drawn only by comparing between groups [13]. The research on PSA focuses on curative effect, and there are few studies on the incidence and related influencing factors. In this paper, through the meta-analysis of binary variables and rates, the differences of risk and incidence between different sexes in PSA and its types are discussed in order to provide evidence-based guidance for the prevention and early rehabilitation of PSA.

Methods

This meta-analysis was registered on the PROSPERO platform with the registration number CRD42022369411: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=369411

Data sources and eligibility criteria

The Embase, PubMed, Cochrane Library and Web of Science were searched from January 1, 2000, to December 1, 2023. The keywords "Stroke", "Cerebral Hemorrhage", "Brain Infarction" and "Aphasia" were combined with their free words in the database. We searched for publications without restrictions on language, or type.

Inclusion criteria

The inclusion criteria were as follows: (1) The research type was observational research. (2) The total number of stroke and aphasia cases and the number of people of different sexes were included. (3) The number of people corresponding to different sexes with PSA was included.

Exclusion criteria: (1) The data of the total number of stroke or aphasia or the number of gender is missing. (2) Inclusion or exclusion of a specific type of aphasia. (3) Aphasia caused by brain trauma, tumor, inflammation, neurodegeneration and other non-stroke causes, and specific relevant data cannot be extracted. (4) Publishing with duplicate data. (5) The data is contradictory, and the original data cannot be obtained after contacting the author. (6) The literature types are non-observational studies such as conferences, scientific and technological achievements, case reports and reviews.

Study selection and data collection processes

According to the inclusion and exclusion criteria, the two authors independently screened the literature and were finally included in the study after browsing the topic primary selection and reading the full text. Four authors collected basic research materials and data, including the basic characteristics of the literature and the number of stroke and aphasia cases in different sexes. In case of dispute, another author re-evaluated it and reached an agreement through discussion.

Quality evaluation

Newcastle–Ottawa Scale was used to evaluate the quality of the included cohort studies and case–control studies, including the selection of study population, comparability between groups and measurement of exposure factors/results. The total score is 9 points, 3 points and below are low quality, 4–6 points are medium quality, and 7 points and above are high quality. The quality evaluation of cross-sectional study uses the evaluation standards of American health care quality and research institutions, with a total of 11 items, in which "Yes" is 1 point, "Unclear" and "No" are 0 points, 3 points and below are low quality, 4–7 points are medium quality, and 8 points and above are high quality. The quality evaluation of all included studies was independently completed by two authors. If there are different opinions, the final result would be decided after full discussion.

Statistical analysis

Stata 16.0 was used for analysis, meta-analysis of binary variables was used to evaluate the risk of PSA and its types, and meta-analysis of rate was used to calculate the incidence of PSA and its types. The results of continuous variables are expressed by the mean ± standard deviation, the binary variables by the odds ratio (OR), and the confidence interval (CI) by 95%. The heterogeneity ($I^2 \leq 50\%$) was analysed by a fixed effect model, and when $I^2 > 50\%$, it was considered that the heterogeneity was large, and the random effect model was selected to analyse the data. The difference was statistically significant when $P \leq 0.05$.

Results

Description of studies

After eliminating duplicate and irrelevant searches, 1988 documents were selected by reading topics and abstracts, and the remaining 36 documents met the requirements by intensive reading of 162 documents. Refer to Fig. 1 for the screening process. Among them, there were 168,259 cases of cerebral stroke (97,081 males and 71,175 females) and 31,058 cases of PSA (17,432 males and 13,626 females) in 31 studies.

There were 1048 patients (544 males and 504 females) in 7 articles involving different sexes and PSA types. There were 300 cases of global aphasia (male 134, female 166), 184 cases of broca aphasia (male 95, female 89), 196 cases of anomic aphasia (male 112, female 84), 142 cases of wernicke aphasia (male 74, female 68), 28 cases of transcortical motor aphasia (male 16, female 12), 48 cases of conductive aphasia (male 28, female 20), 36 cases of transcortical mixed aphasia (male 22, female 14) and 43 cases of transcortical sensory aphasia (male 26, female 17). There were 67 cases of other aphasia, including 9 cases of crossed aphasia (male 2, female 7), 4 cases of isolated aphasia (male 1, female 3), 3 cases of basal ganglia aphasia (male 1, female 2) and the classification of 51 cases of aphasia (male 29, female 22) was unclear.

The people included in the study came from Canada, Italy, Greece, Japan, Croatia, Norway, Britain, the United States, Sweden, Switzerland, Austria, Brazil, Belgium, Denmark, India, Chile, Spain, France and China. In 19 countries, the number of patients with left cerebral ischemic stroke is the largest, and the incidence of stroke is diagnosed by tomography or magnetic resonance imaging. The PSA was judged by the Boston Diagnostic Aphasia Test, Western Aphasia Test, Differential Diagnosis of Aphasia in Minnesota, National Institutes of Health Stroke Scale (NIHSS), Aachen aphasia test, Canadian Neurometric Scale, French Aphasia Screening Test, Petname ruby Afasi Norwegian Standard, AIIMS aphasia examination test, and Quick Aphasia Battery. See Table 1.

Risk of bias in included studies

A total of 36 articles were included, including 27 high-quality articles and 9 medium-quality articles. The main factor affecting the quality of cohort studies and cross-sectional studies is the follow-up part, and eight studies considered the relative long-term and adequacy of follow-up. Comparability between exposed/case groups and nonexposed/control groups is also an important part of the score. Fourteen studies fully compared the general data affecting the results and considered the

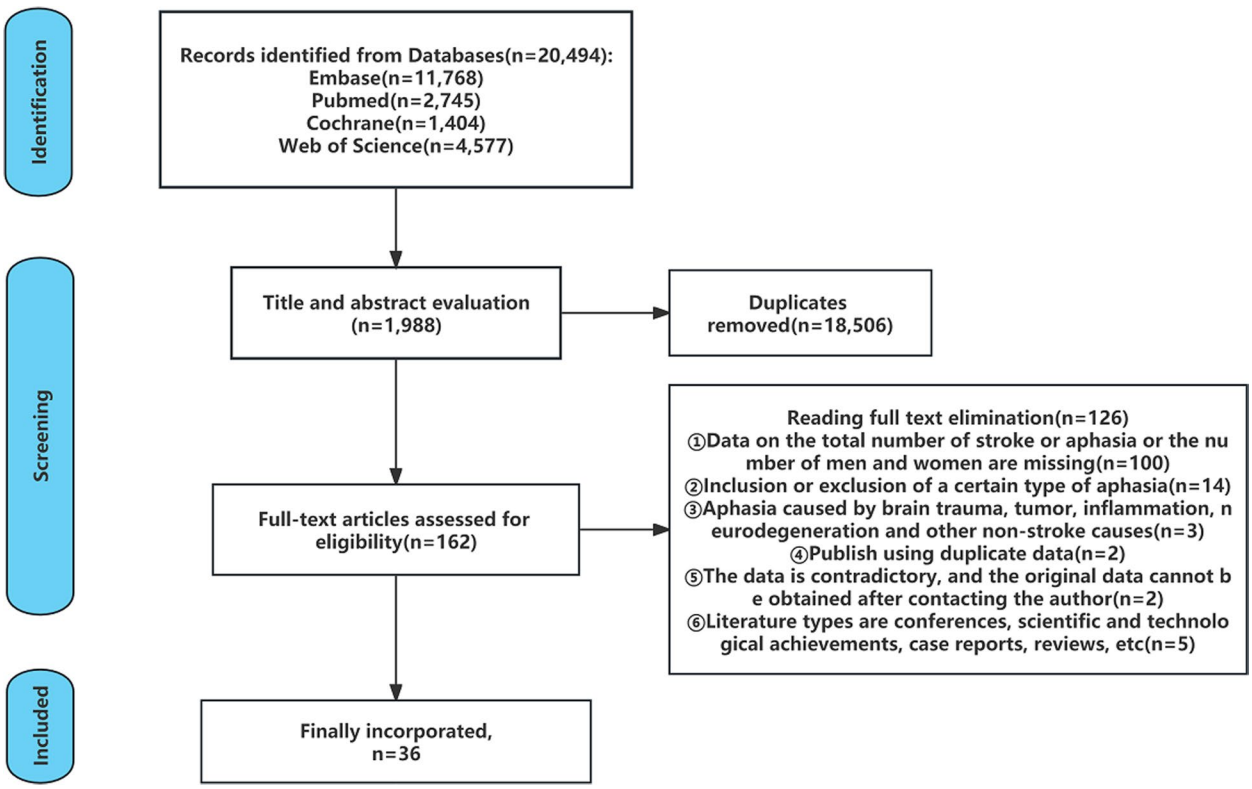

Fig. 1 Flow diagram

Table 1 Basic characteristics and quality evaluation results of the included documents

Author (year)	Country	Age	Research type	Number of stroke types		Aphemia judgment method	Document quality score
				ischemia	bleed		
Bhatnagar(2002) [14]	India	-	cohort	-	-	①	6
Carlo(2002) [15]	Italy	71.8 ± 12.6	cohort	2740	545	-	7
Godefroy(2002) [16]	France	62 ± 16	cohort	263	45	②	7
Trapl(2004) [17]	Austria	71.6 ± 12.08	cohort	-	-	③	6
Pedersen(2004) [18]	Denmark	75.8 ± 10.4	cohort	205	-	④	8
Engelter(2006) [19]	Switzerland	-	case–control	-	-	⑤	6
Inatomi(2008) [8]	Japan	-	cohort	130	0	⑥	7
Kyrozis(2009) [20]	Greece	-	cohort	-	-	-	7
Brkić(2009) [21]	Croatia		cohort	156	38	-	6
Bersano(2009) [22]	Italy	-	cohort	2154	320	-	8
Naess(2009) [23]	Norway	-	cohort	20	0	⑦	9
Kyrozis(2009) [20]	Greece	-	cohort	158	94	-	6
Tsouli(2009) [24]	Greece	-	cohort	2022	275	-	7
Dickey(2010)[25]	Canada	73 ± 13	case–control	4237	700	⑧	6
Gialanella(2011) [26]	Italy	67.4 ± 9.8	cohort	82	23	③	7
Gialanella(2011) [27]	Italy	-	cohort	103	28	③	7
Hilari(2011) [28]	Britain	69.5 ± 12.5	cohort	75	12	⑥⑨	9
Gialanella(2011)	Italy	-	cohort	205	57	③	6
Kadojić(2012) [13]	Croatia	-	cohort	75	0	②	6
Flowers(2013) [29]	Canada	70.9 ± 13	cohort	68	0	-	7
Schnakers(2015) [30]	Belgium	66.29 ± 12.66	transverse section	4	20	③	8
Boehme(2016) [31]	America	-	cohort	934	90	⑥	7
Flowers(2017) [32]	Canada	70.8 ± 13.3	cohort	52	0	-	7
González Mc(2017) [33]	Chile	66 ± 20	cohort	142	0	-	5
Ginex(2017) [34]	Italy	75.5 ± 12.1	cohort	33	15	③	7
Lima(2019) [12]	Brazil	69.84 ± 13.88	case–control	79	0	⑥	6
Cock(2020) [7]	Belgium	74 ± 13	cohort	34	0	②	7
Gonzalez(2020) [35]	Chile	57.37 ± 15.56	cohort	-	-	②④	7
Rudolph(2020) [36]	Spain	50.05 ± 9.21	cohort	130	0	⑥	6
Xu(2021) [37]	China	61.1 ± 11.9	transverse section	180	34	④	10
Goldberg(2021) [38]	America	59.2 ± 13.0	cohort	122	0	②④	7
Grönberg(2022) [39]	Sweden	-	case–control	91	0	⑥	8
Lin(2022) [40]	Taiwan	-	cohort	11,494	5569	⑥	8
Grönberg(2022) [4]	Sweden	-	cohort	308	0	⑩	7
Wilson(2022) [41]	America	-	cohort	174	68	-	8
Brogan(2023) [42]	Australian	-	cohort	1658	206	-	7

① AIIMS aphasia examination test; ② Boston Diagnostic Aphasia Test (BDAE); ③ Aachen aphasia test (AAT); ④ Western Aphasia Test (WAB); ⑤ Differential diagnosis of Minnesota aphasia; ⑥ National Institutes of Health Stroke Scale (NIHSS); ⑦ Pet-name ruby Afasi Norwegian Standard (NGA); ⑧ Canadian Neurometric Scale; ⑨ French Aphasia Screening Test (FAST); ⑩Quick Aphasia Battery(QAB)

influence of confounding factors, which improved the referential of the study. Only 18 studies accurately provided the statistical data of PSA patients' age, and other studies failed to write according to the standard, which affected the comparability score between groups and reduced the accuracy of experimental results.

Meta-analysis

Sex and risk of poststroke aphasia

Taking female PSA group after stroke as the exposure group, 31 studies were analyzed by meta-analysis of binary variables, and $I^2 = 84.5\%$ (Supplementary Fig. 1) thought that the heterogeneity was high, and the source of heterogeneity was not shown by sensitivity analysis (Supplementary Fig. 2). Excluding Lin et al.' s research

[40], the heterogeneity is less than 50%. The results show that the risk of PSA in women is higher than that in men, which is 1.23 times that in men (OR = 1.23, 95%CI = 1.19–1.29, $P < 0.05$). See Fig. 2.

Sex and incidence of poststroke aphasia

31 studies mentioned the total number of stroke and PSA, and the meta-analysis of utilization rate showed that the incidence of PSA was 34% ($I^2 = 99.5\%$, 95%CI = 0.29–0.38, $P < 0.001$), as shown in Fig. 3. Sensitivity analysis did not find the source of heterogeneity (Supplementary Fig. 3).

31 studies mentioned male stroke and the total number of PSA, and the meta-analysis of the utilization rate showed that the incidence of male PSA was 31% ($I^2 = 99.0\%$, 95%CI = 0.27–0.36, $P < 0.001$), as shown in Fig. 4. Sensitivity analysis did not find the source of heterogeneity (Supplementary Fig. 4).

31 studies mentioned the total number of female stroke and PSA, and the meta-analysis of utilization rate showed that the incidence of female PSA was 36% ($I^2 = 99.2\%$, 95%CI = 0.31–0.42, $P < 0.001$), as shown in Fig. 5. Sensitivity analysis did not find the source of heterogeneity (Supplementary Fig. 5).

Sex and risk, incidence of type of poststroke aphasia

Global aphasia

A meta-analysis of dichotomous variables in 7 studies showed that the risk of global aphasia was 1.20 times higher in female than in male (OR = 1.27, 95%CI = 0.95–1.70, $P = 0.734$), see Supplementary Fig. 6. A meta-analysis of rates in 7 studies and by gender subgroup, showed the incidence of global aphasia 31% ($I^2 = 93.6\%$, 95%CI = 0.21–0.40, $P < 0.001$), 29% ($I^2 = 93.5\%$,95%CI = 0.16–0.42, $P < 0.001$) in male, and

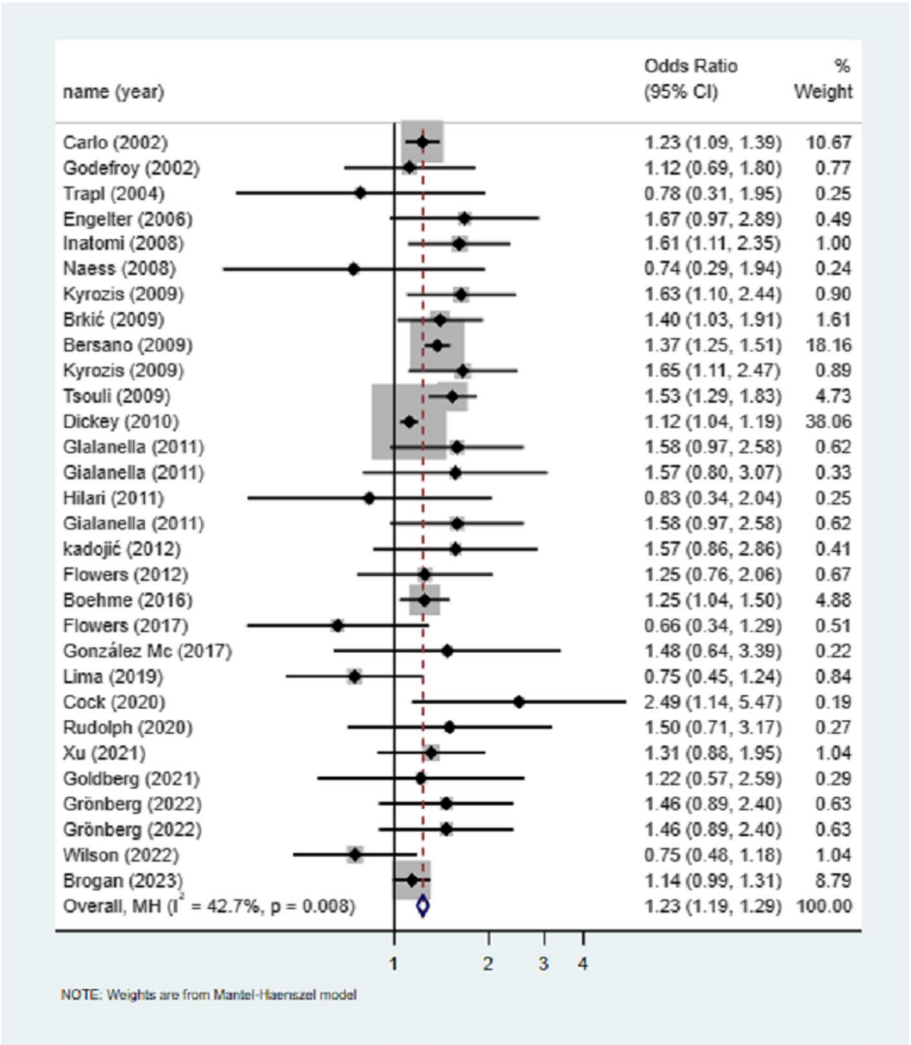

Fig. 2 Sex and the risk of poststroke aphasia

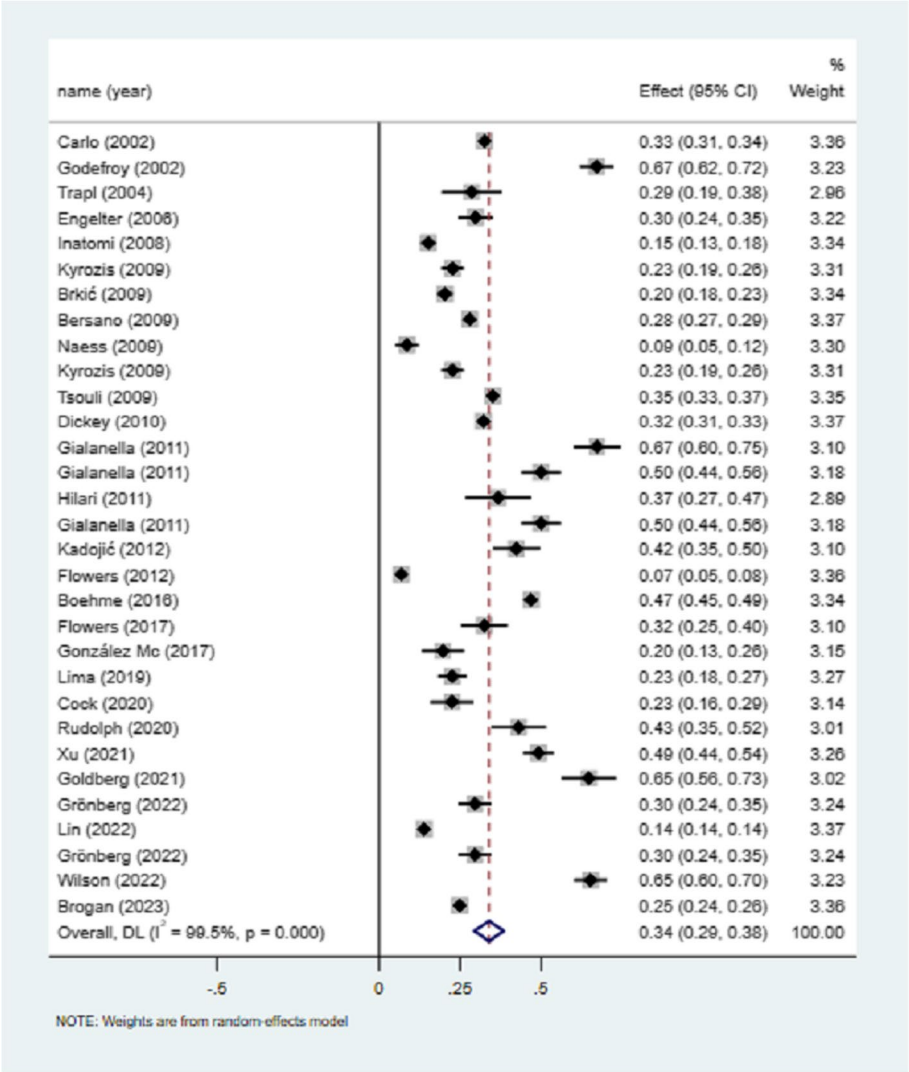

Fig. 3 Incidence of poststroke aphasia

32% (I^2 = 94.0%,95%CI = 0.17–0.48, P < 0.001) in female, see Fig. 6.

Broca aphasia

A meta-analysis of dichotomous variables in 7 studies showed that the risk of broca aphasia was 1.20 times higher in female than in male (OR = 1.20, 95%CI = 0.86–1.69, P = 0.816), see Supplementary Fig. 7. A meta-analysis of rates in 7 studies and by gender subgroup, showed the incidence of broca aphasia 18% (I^2 = 68.8%, 95%CI = 0.14–0.22, P < 0.001), 17% (I^2 = 77.2%,95%CI = 0.10–0.24, P < 0.001) in male, and 19% (I^2 = 60.4%,95%CI = 0.13–0.25, P < 0.05) in female, see Fig. 7.

Anomic aphasia

A meta-analysis of dichotomous variables in 7 studies showed that the risk of anomic aphasia was 1.33 times higher in male than in female (OR = 1.33, 95%CI = 0.95–1.86, P = 0.305), see Supplementary Fig. 8. A meta-analysis of rates in 7 studies and by gender subgroup, showed the incidence of anomic aphasia 17% (I^2 = 92.2%, 95%CI = 0.10–0.23, P < 0.001), 19% (I^2 = 90.5%, 95%CI = 0.09–0.30, P < 0.001) in male, and 14% (I^2 = 92.4%, 95%CI = 0.05–0.24, P < 0.001) in female, see Fig. 8.

Wernicke aphasia

A meta-analysis of dichotomous variables in 7 studies showed that the risk of wernicke aphasia was 1.02 times higher in female than in male (OR = 1.02,

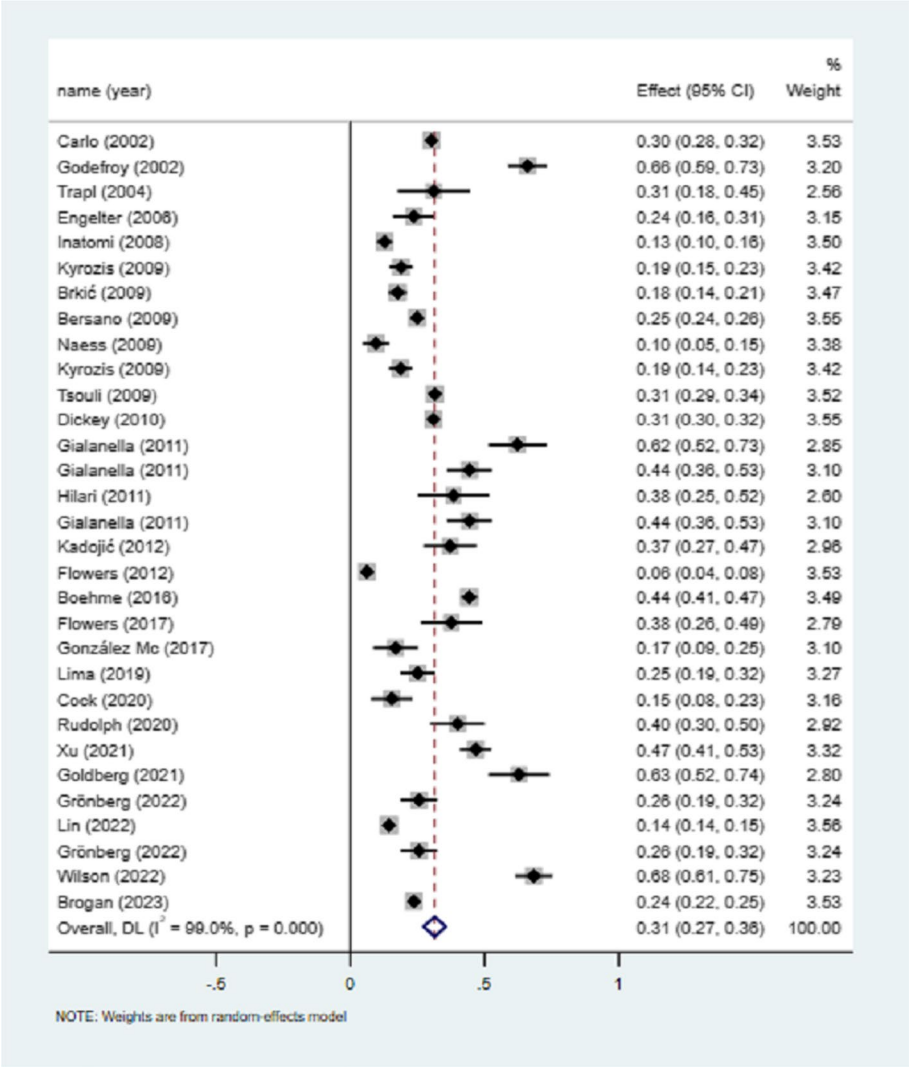

Fig. 4 Incidence of poststroke aphasia in male

95%CI = 0.71–1.47, $P = 0.427$), see Supplementary Fig. 9. A meta-analysis of rates in 7 studies and by gender subgroup, showed the incidence of wernicke aphasia 13% ($I^2 = 9.9\%$, 95%CI = 0.11–0.15, $P = 0.346$), 13% ($I^2 = 27.5\%$, 95%CI = 0.09–0.16, $P = 0.219$) in male, and 13% ($I^2 = 0.0\%$, 95%CI = 0.10–0.16, $P = 0.418$) in female, see Fig. 9.

Transcortical mixed aphasia

A meta-analysis of dichotomous variables in 3 studies showed that the risk of transcortical mixed aphasia was 1.10 times higher in male than in female (OR = 1.10, 95%CI = 0.53–2.27, $P = 0.756$), see Supplementary Fig. 10. A meta-analysis of rates in 3 studies and by gender subgroup, showed the incidence of transcortical mixed aphasia 7% ($I^2 = 84.8\%$, 95%CI = 0.02–0.12, $P < 0.001$), 8% ($I^2 = 89.5\%$, 95%CI = 0.03–0.19, $P < 0.001$) in male, and 8% ($I^2 = 84.5\%$, 95%CI = 0.04–0.20, $P < 0.001$) in female, see Fig. 10.

Conductive aphasia

A meta-analysis of dichotomous variables in 5 studies showed that the risk of conductive aphasia was 1.15 times higher in male than in female (OR = 1.15, 95%CI = 0.62–2.11, $P = 0.380$), see Supplementary Fig. 11. A meta-analysis of rates in 5 studies and by gender subgroup, showed the incidence of conductive aphasia 5% ($I^2 = 56.4\%$, 95%CI = 0.21–0.40, $P < 0.05$), 4% ($I^2 = 71.5\%$, 95%CI = 0.01–0.07, $P < 0.05$) in male, and 5% ($I^2 = 0.0\%$, 95%CI = 0.03–0.07, $P = 0.454$) in female, see Fig. 11.

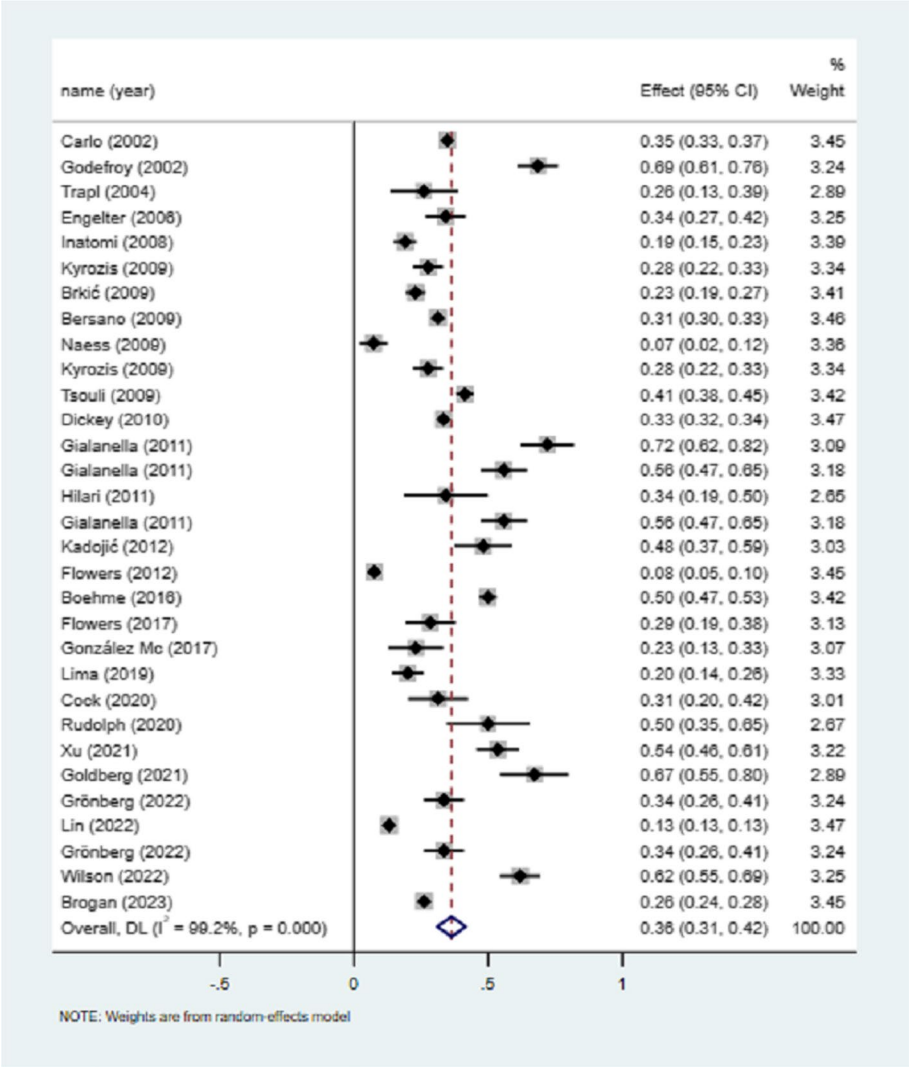

Fig. 5 Incidence of poststroke aphasia in female

Transcortical sensory aphasia

A meta-analysis of dichotomous variables in 4 studies showed that the risk of transcortical sensory aphasia was 1.54 times higher in male than in female (OR = 1.54, 95%CI = 0.82–2.89, $P = 0.514$), see Supplementary Fig. 12. A meta-analysis of rates in 4 studies and by gender subgroup, showed the incidence of transcortical sensory aphasia 4% ($I^2 = 60.2\%$, 95%CI = 0.02–0.06, $P < 0.05$), 5% ($I^2 = 75.3\%$, 95%CI = 0.02–0.06, $P < 0.05$) in male, and 3% ($I^2 = 40.0\%$, 95%CI = 0.01–0.05, $P = 0.172$) in female, see Fig. 12.

Transcortical motor aphasia

A meta-analysis of dichotomous variables in 5 studies showed that the risk of transcortical motor aphasia was 1.21 times higher in male than in female (OR = 1.21, 95%CI = 0.55–2.70, $P = 0.498$), see Supplementary Fig. 13. A meta-analysis of rates in 5 studies and by gender subgroup, showed the incidence of transcortical motor aphasia 3% ($I^2 = 50.8\%$, 95%CI = 0.01–0.04, $P = 0.058$), 3% ($I^2 = 64.8\%$, 95%CI = 0.00–0.06, $P < 0.05$) in male, and 3% ($I^2 = 43.2\%$, 95%CI = 0.01–0.05, $P = 0.172$) in female, see Fig. 13.

Other type of aphasia

A meta-analysis of dichotomous variables in two studies showed that sex had no predictive significance of developing risk in other types of aphasia (OR = 1.00, 95%CI = 0.57–1.74, $P = 0.489$), as shown in Supplementary Fig. 14. A meta-analysis of rates in 2 studies and by gender subgroup, showed the incidence of other types of

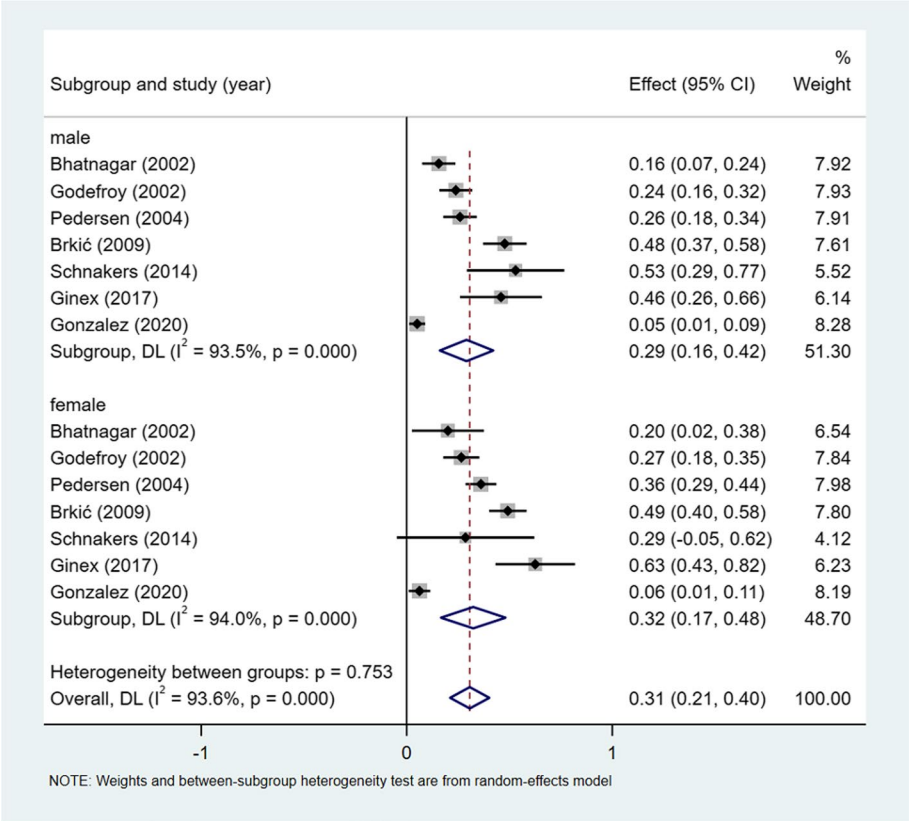

Fig. 6 Incidence of global aphasia

aphasia 15% ($I^2=96.6\%$, 95%CI = 0.06–0.24, $P<0.001$), 17% ($I^2=98.0\%$, 95%CI = 0.15–0.48, $P<0.001$) in male, and 16% ($I^2=97.4\%$, 95%CI = 0.13–0.46, $P<0.001$) in female, see Fig. 14.

Discussion

In this paper, 168,259 stroke patients were analyzed by meta-analysis, and the results showed that the risk of PSA in female was significantly higher than that in male, which was 1.23 times that in male. This meta-analysis showed that the total incidence of PSA was 34%, which was within the range of 13%-35% estimated by previous studies [28, 29]. The incidence of PSA is affected by diagnostic criteria, and the results are different. At present, there is no unified standard for PSA diagnosis. The aphasia quotient is calculated by weighting the four tests of spontaneous language, auditory comprehension, retelling and naming. The lower the score, the more serious the injury. In other countries, the ninth item of the NIHSS is used to evaluate PSA, and the score is simply given according to the severity of aphasia [8]. The higher the score, the more serious the injury, and it is easy to miss the diagnosis of patients with mild aphasia [39].

The gender difference in the incidence of PSA is related to the bilateralization of language functional areas in the female brain. In the population, 96%-99% of right-handed people and 60% of left-handed people are located in the left brain [43]. In recent years, more scholars have tried to explore the importance of the activation of the right brain region in improving aphasia. Chang et al.[44] found that a patient with global aphasia without hemiplegia after left cerebral stroke can restore oral fluency by activating the right frontal lobe. In the critical period when fetal language controls the development of brain regions, it is regulated by sex hormones, resulting in differences in hemispheric structure and language processing [45]. The development of the brain tends to mature in adolescence, when the testosterone level of boys is 20 times that of girls, the estradiol level has little difference. Abnormal sex hormones are often accompanied by speech disorders [46, 47]. Functional magnetic resonance imaging (fMRI) was used to study the activated brain regions in language processing, and it was found that men only activated the left side. While women activated both sides, suggesting that women activated extensive brain regions, resulting in gender differences in PSA incidence [48].

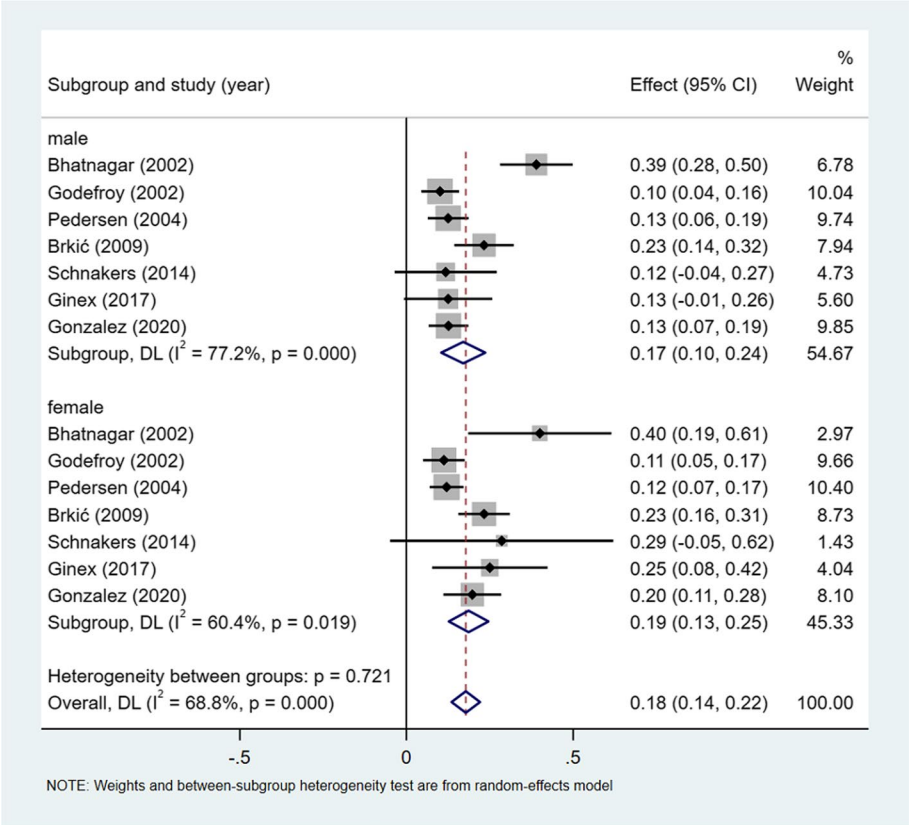

Fig. 7 Incidence of broca aphasia

There are also studies that the difference in incidence between men and women is related to the age of onset, and there is an enormous age difference between men and women in PSA.[20] This showed that women are often older than men when they are sick. The analysis by Wallentin et al.[11] shows that the sex ratio of PSA in different age groups is significantly different. The sex ratio of patients under 64 years old was 1.04, that of patients aged 64–74 years old was 1.08, that of patients aged 75–84 years old was 1.16 and that of patients over 84 years old was 1.22. With increasing age, the prevalence of PSA in women gradually increased. Women have more ability to keep healthy than men, the age-standardized mortality rate of women is lower than that of men in the same year.There were more women in the long-lived population [49]. Age is a risk factor for PSA, and 75%-80% of strokes occur in patients over 65 years old [20]. The median age of female(78) onset is higher than that of male(71) onset.[50] Kadojić et al.[13] found that the prevalence of PSA in women over 85 years old increased by 7.5 times compared with that in men over 65 years old and only increased by 2 times.

Although it is generally believed that the location and size of stroke are the decisive factors of PSA types. Some studies have shown that 63.5% of PSA classification is not completely related to the damage of classical language functional areas, and it needs to be supported by a complete brain semantic network system [51–53]. PSA often causes other serious poststroke complications, among which patients with nonfluent aphasia are usually accompanied by poor motor function and prognosis recovery [26, 54, 55]. There was no authoritative classification standard for PSA types, and 26.5% of aphasia cases cannot be classified [52].

The NIHSS score of women at admission is generally lower than that of men, and the degree of stroke is more serious, which gradually increases with age [50]. Lee and others[56] think that NIHSS score can predict aphasia quotient, indicating that stroke severity is an important variable of PSA degree. Global aphasia is the most common PSA type [4, 13]. Due to the connectivity of the whole brain language network and the abnormal connection mode of key language intervals, its language fluency, listening comprehension and

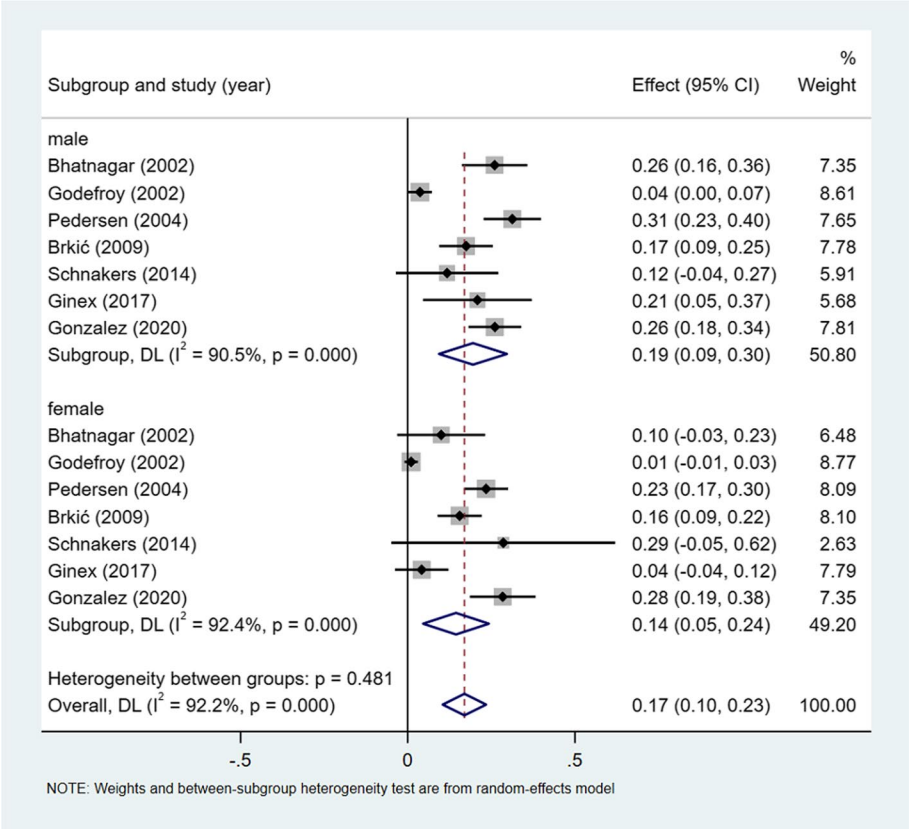

Fig. 8 Incidence of anomic aphasia

retelling ability are poor, which is the most serious aphasia [35]. The language fluency of different sexes is affected by the volume and density of gray matter [57]. The brain volume, volume and density of gray matter in men are larger than those in women, and women are more likely to damage more gray matter in severe stroke, which affects language fluency [58]. During stroke, diffuse depolarization and cytotoxic edema occur in the gray matter of the brain, which mediates the death of neurons and damages the gray matter [59]. This paper thought that the incidence of female (28%) global aphasia was significantly higher than that of male (27%), but there was no research on the influence and correlation of sex in a large sample of patients.

Ellis et al.[60] showed that age is related to PSA types, and the incidence of broca aphasia is higher in young people. The increase in age is accompanied by extensive changes in brain structure, which often leads to a decline in language competence, but the understanding function is preserved [61]. The most classic type of nonfluent aphasia is broca aphasia, which is characterized by poor oral fluency and retelling ability and relatively good listening and understanding ability, which damages broca's brain area and affects the continuity of language [62, 63]. After analysis by Sharma et al.[10], it was found that the incidence of broca aphasia in men (27.4%) was significantly higher than that in women (19.2%), with an average age of 61.9 years. At present, the mechanism is not clear. Sharma[10] thinks that in addition to the differences in onset age and hemispheric structure between men and women, the damaged vascular area also needs to be further explored. Some studies have also shown that the incidence of broca aphasia in men in all age groups is higher than that in women, and further research and discussion are needed.

Anomic aphasia is aphasia characterized by an inability to name, and other language abilities are relatively complete. The incidence rate is relatively low in acute stroke, and it is usually the outcome type of other aphasia. There was a significant positive

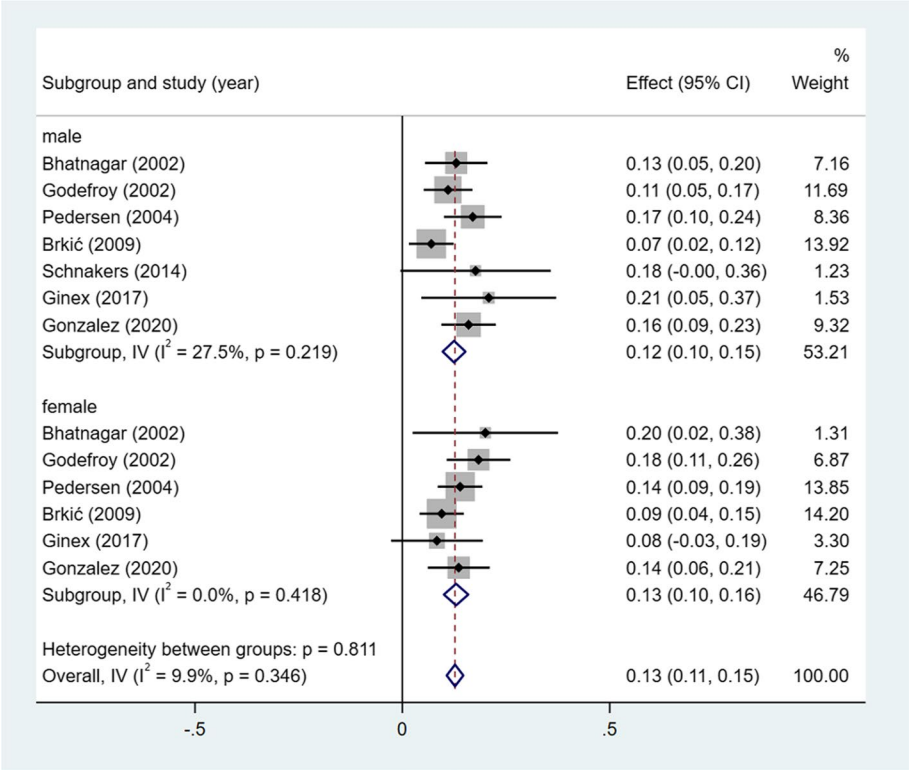

Fig. 9 Incidence of wernicke aphasia

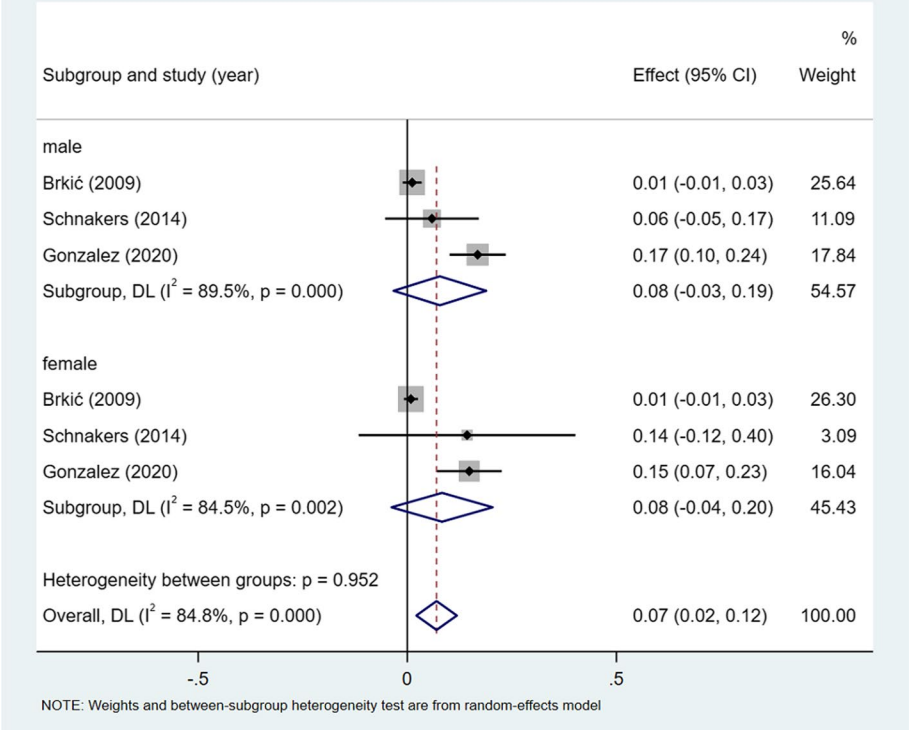

Fig. 10 Incidence of transcortical mixed aphasia

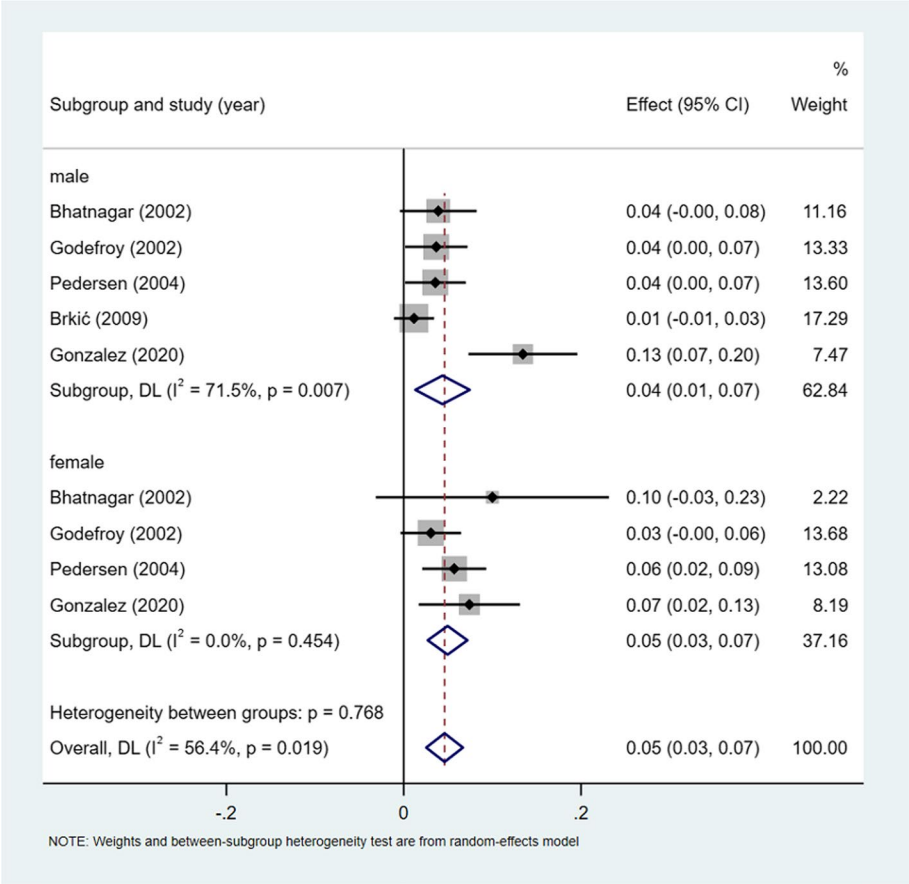

Fig. 11 Incidence of conductive aphasia

correlation between naming accuracy and language span length (r = 0.732), and word naming is considered a short-term memory of speech, which is influenced by the temporary activation of language representation [64]. Female scores in short-term memory are significantly higher than male, their word recall ability and the number of single memories are superior, and their recovery after injury is also better than that of male. In this paper, the incidence of anomic aphasia in men (18%) was higher than that in women (16%), which is closely related to the difference in naming between men and women before injury [65, 66].

The incidence of transcortical motor aphasia, transcortical mixed aphasia, other type of aphasia, conductive aphasia and transcortical sensory aphasia is less than 10%. However, due to the relatively low incidence, previous observational studies have not reached the same conclusion, and the specific mechanism needs to be explored by more scholars. Other types of aphasia in this paper include cross-aphasia, isolated aphasia and basal ganglia aphasia. But the conclusion after meta-analysis suggests that there is no difference between the sexes, and there is no statistical significance. Perhaps because the number of people suffering from other aphasia is relatively small, it is not considered that the incidence of other aphasia is affected by gender. There is no significant gender difference among wernicke aphasia, conductive aphasia and transcortical sensory aphasia, and it is not considered that gender is related to them.

Although sex can't predict the occurrence of stroke, the incidence of stroke in male is higher than that in female worldwide [67]. This leads researchers to pay more attention to reducing the risk factors of stroke in male, while ignoring the physical condition of female. Through meta-analysis, this study holds that the probability of aphasia in female after stroke is higher than that in male, and the severity is also higher than that in male, which is caused by the damage of language function areas in both brains of women after stroke.

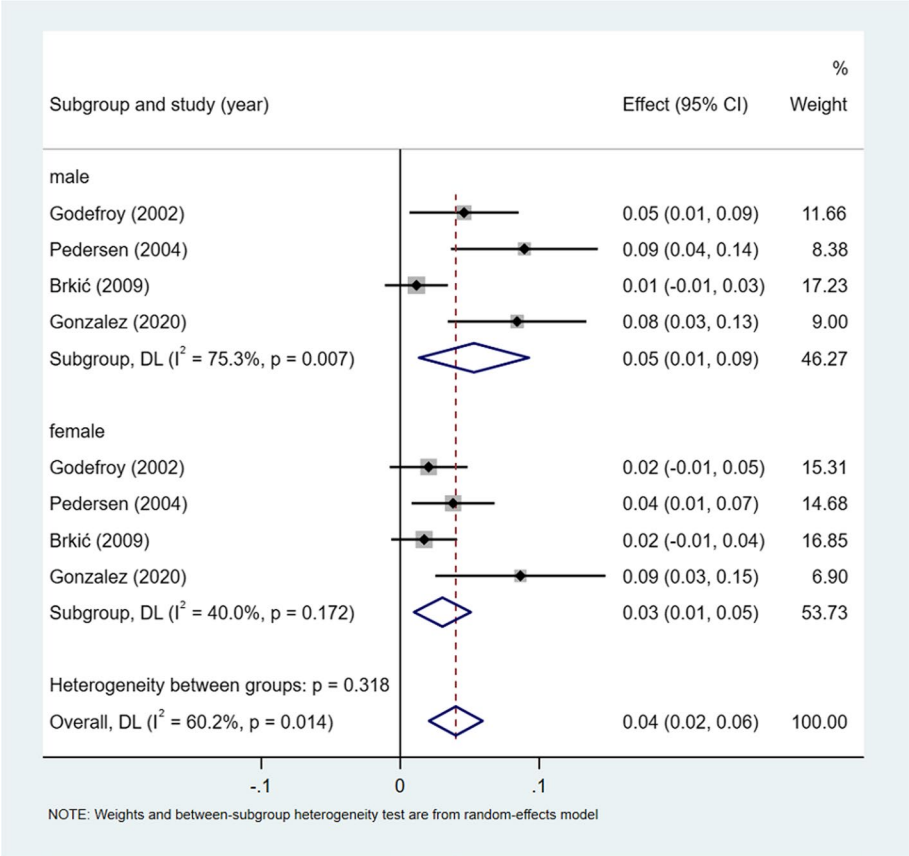

Fig. 12 Incidence of transcortical sensory aphasia

This requires medical workers to pay special attention to training female right language function area in daily propaganda to prevent stroke and serious PSA. The gender difference in the types of PSA can guide doctors to use physical therapy equipment to carry out early rehabilitation of PSA in the early stage of stroke when patients are in a state of continuous coma. Of course, this requires the auxiliary examination of imaging to confirm the damaged brain area of the patient.

Study limitations

In this paper, a large number of similar studies are analysed, but due to the limitations of literature types. It is impossible to correct for confounding factors such as age, stroke type and injured hemisphere. Subsequent scholars can eliminate the influence of confounding factors through large sample size investigations and studies and obtain more accurate results. The included studies come from 19 countries and regions, and there are great differences among them. It is difficult to completely eliminate their heterogeneity through statistical methods, and the statistical analysis from international cooperation is expected in the future.

Conclusion

In summary, there are differences in the incidence and types of PSA between male and female. The risk of PSA in female is higher than that in male, which is related to the activation of bilateral brain language functional areas and the age at onset. The incidence of global aphasia and broca aphasia is high in female, and the incidence of anomic aphasia is higher in male. Different sexes cause differences in aphasia types, which are influenced by the degree of gray matter injury, age of onset and activation of language representation. This study can guide clinical workers to carry out gender-specific preventive intervention for people at risk of stroke, and to recover as soon as possible in different aphasia types for different sexes after stroke.

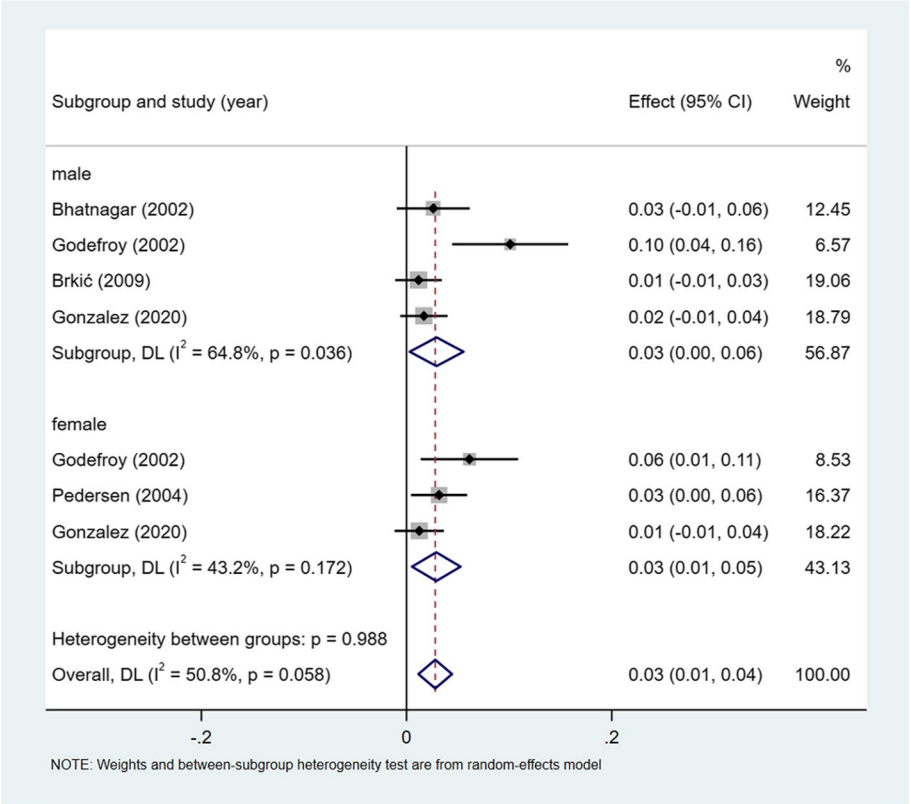

Fig. 13 Incidence of transcortical mortor aphasia

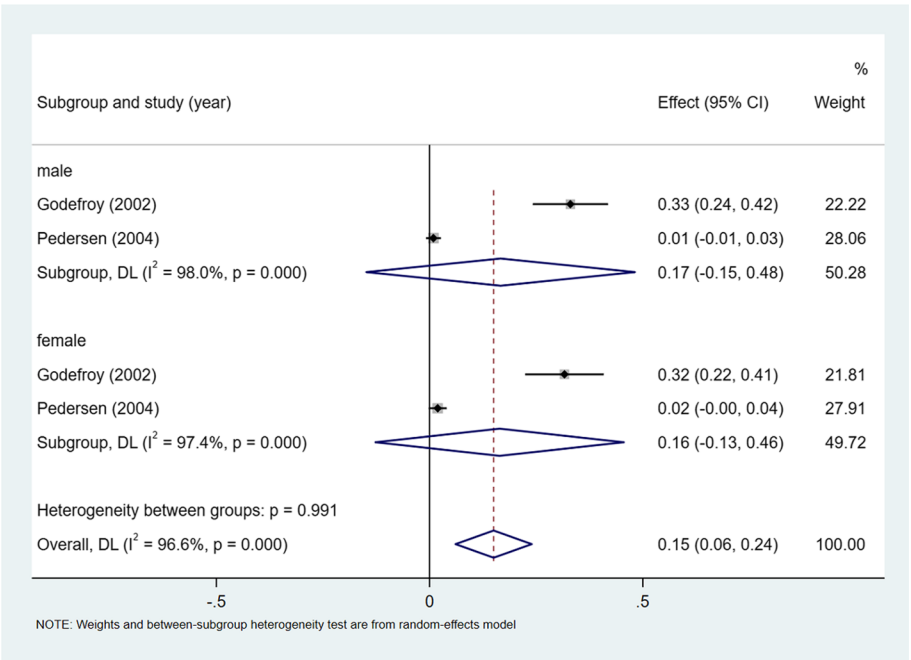

Fig. 14 Incidence of other type of aphasia

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-024-04765-0.

Additional file 1. Supplementary Figure 1. Sex and the risk of post-stroke aphasia (before exclusion). **Supplementary Figure 2.** Sensitivity analysis of sex and the risk of poststroke aphasia. **Supplementary Figure 3.** Sensitivity analysis of incidence of poststroke aphasia. **Supplementary Figure 4.** Sensitivity analysis of incidence of poststroke aphasia in male. **Supplementary Figure 5.** Sensitivity analysis of incidence of poststroke aphasia in female. **Supplementary Figure 6.** Sex and the risk of global aphasia. **Supplementary Figure 7.** Sex and the risk of broca aphasia. Supplementary Figure 8. Sex and the risk of anomic aphasia. **Supplementary Figure 9.** Sex and the risk of wernicke aphasia. **Supplementary Figure 10.** Sex and the risk of transcortical mixed aphasia. Supplementary Figure 11. Sex and the risk of conductive aphasia. **Supplementary Figure 12.** Sex and the risk of transcortical sensory aphasia. **Supplementary Figure 13.** Sex and the risk of transcortical mortor aphasia. **Supplementary Figure 14.** Sex and the risk of other type of aphasia.

Author's contributions

The study was designed jointly with Ting-ting Li and Zhang Ping-ping. Ting-ting Li completed the data analysis and manuscript writing. Xiao-wen Wang and Zhong-guang Sun commented on and edited the research. The data and literature collection was completed by Ming-chen Zhang and Hui Zhang. Hong-ying Wang, Ying Yuan and Shan-lin Wu reviewed and confirmed the collected data. Ting-ting Li, Xiao-wen Wang and Zhong-guang Sun reviewed the final draft of the manuscript.

Funding

This work was supported by the Youth Project of Shandong Natural Science Foundation [grant number ZR2022QH094] and the Student Innovation and Entrepreneurship Training Program Project of Shandong Province in 2023 [grant number S202310438041S].

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due to space limitation but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]School of Rehabilitation Medicine, Shandong Second Medical University, Weifang, China. [2]Shanghai University of Medicine & Health Sciences, Shanghai University of Traditional Chinese Medicine, Shanghai, China.

Received: 13 October 2023 Accepted: 31 January 2024
Published online: 04 March 2024

References

1. Feigin VL, Brainin M, Norrving B, Martins S, Sacco RL, Hacke W, Fisher M, Pandian J, Lindsay P. World Stroke Organization (WSO): Global Stroke Fact Sheet 2022. Int J Stroke. 2022;17(1):18–29.
2. Stipancic KL, Borders JC, Brates D, Thibeault SL. Prospective Investigation of Incidence and Co-Occurrence of Dysphagia, Dysarthria, and Aphasia Following Ischemic Stroke. Am J Speech Lang Pathol. 2019;28(1):188–94.
3. Wu C, Qin Y, Lin Z, Yi X, Wei X, Ruan Y, He J. Prevalence and Impact of Aphasia among Patients Admitted with Acute Ischemic Stroke. J Stroke Cerebrovasc Dis. 2020;29(5):104764.
4. Grönberg A, Henriksson I, Stenman M, Lindgren AG. Incidence of Aphasia in Ischemic Stroke. Neuroepidemiology. 2022;56(3):174–82.
5. Flowers HL, Skoretz SA, Silver FL, Rochon E, Fang J, Flamand-Roze C, Martino R. Poststroke Aphasia Frequency, Recovery, and Outcomes: A Systematic Review and Meta-Analysis. Arch Phys Med Rehabil. 2016;97(12):2188-2201.e2188.
6. Mihejeva I, Vētra A, Bērziņa G. Factors associated with long-term mortality for stroke unit patients in Latvia. Brain Behav. 2018;8(12):e01152.
7. De Cock E, Batens K, Hemelsoet D, Boon P, Oostra K, De Herdt V. Dysphagia, dysarthria and aphasia following a first acute ischaemic stroke: incidence and associated factors. Eur J Neurol. 2020;27(10):2014–21.
8. Inatomi Y, Yonehara T, Omiya S, Hashimoto Y, Hirano T, Uchino M. Aphasia during the acute phase in ischemic stroke. Cerebrovasc Dis. 2008;25(4):316–23.
9. Watila MM, Balarabe SA. Factors predicting post-stroke aphasia recovery. J Neurol Sci. 2015;352(1–2):12–8.
10. Sharma S, Briley PM, Wright HH, Perry JL, Fang X, Ellis C. Gender differences in aphasia outcomes: evidence from the AphasiaBank. Int J Lang Commun Disord. 2019;54(5):806–13.
11. Wallentin M. Sex differences in post-stroke aphasia rates are caused by age. A meta-analysis and database query. PLoS One. 2018;13(12):e0209571.
12. Lima RR, Rose ML, Lima HN, Cabral NL, Silveira NC, Massi GA. Prevalence of aphasia after stroke in a hospital population in southern Brazil: a retrospective cohort study. Top Stroke Rehabil. 2020;27(3):215–23.
13. Kadojić D, Bijelić BR, Radanović R, Porobić M, Rimac J, Dikanović M. Aphasia in patients with ischemic stroke. Acta Clin Croat. 2012;51(2):221–5.
14. Bhatnagar SC, Jain SK, Bihari M, Bansal NK, Pauranik A, Jain DC, Bhatnagar MK, Meheshwari MC, Gupta M, Padma MV. Aphasia type and aging in Hindi-speaking stroke patients. Brain Lang. 2002;83(2):353–61.
15. Di Carlo A, Lamassa M, Baldereschi M, Pracucci G, Basile AM, Wolfe CD, Giroud M, Rudd A, Ghetti A, Inzitari D. Sex differences in the clinical presentation, resource use, and 3-month outcome of acute stroke in Europe: data from a multicenter multinational hospital-based registry. Stroke. 2003;34(5):1114–9.
16. Godefroy O, Dubois C, Debachy B, Leclerc M, Kreisler A. Vascular aphasias: main characteristics of patients hospitalized in acute stroke units. Stroke. 2002;33(3):702–5.
17. Trapl M, Eckhardt R, Bosak P, Brainin M. Early recognition of speech and speech-associated disorders after acute stroke. Wien Med Wochenschr. 2004;154(23–24):571–6.
18. Pedersen PM, Vinter K, Olsen TS. Aphasia after stroke: type, severity and prognosis The Copenhagen aphasia study. Cerebrovasc Dis. 2004;17(1):35–43.
19. Engelter ST, Gostynski M, Papa S, Frei M, Born C, Ajdacic-Gross V, Gutzwiller F, Lyrer PA. Epidemiology of aphasia attributable to first ischemic stroke: incidence, severity, fluency, etiology, and thrombolysis. Stroke. 2006;37(6):1379–84.
20. Kyrozis A, Potagas C, Ghika A, Tsimpouris PK, Virvidaki ES, Vemmos KN. Incidence and predictors of post-stroke aphasia: the Arcadia Stroke Registry. Eur J Neurol. 2009;16(6):733–9.
21. Brkić E, Sinanović O, Vidović M, Smajlović D. Incidence and clinical phenomenology of aphasic disorders after stroke. Med Arh. 2009;63(4):197–9.
22. Bersano A, Burgio F, Gattinoni M, Candelise L. Aphasia burden to hospitalised acute stroke patients: need for an early rehabilitation programme. Int J Stroke. 2009;4(6):443–7.
23. Naess H, Hammersvik L, Skeie GO. Aphasia among young patients with ischemic stroke on long-term follow-up. J Stroke Cerebrovasc Dis. 2009;18(4):247–50.
24. Tsouli S, Kyritsis AP, Tsagalis G, Virvidaki E, Vemmos KN. Significance of aphasia after first-ever acute stroke: impact on early and late outcomes. Neuroepidemiology. 2009;33(2):96–102.
25. Dickey L, Kagan A, Lindsay MP, Fang J, Rowland A, Black S. Incidence and profile of inpatient stroke-induced aphasia in Ontario. Canada Arch Phys Med Rehabil. 2010;91(2):196–202.

26. Gialanella B. Aphasia assessment and functional outcome prediction in patients with aphasia after stroke. J Neurol. 2011;258(2):343–9.
27. Gialanella B, Bertolinelli M, Lissi M, Prometti P. Predicting outcome after stroke: the role of aphasia. Disabil Rehabil. 2011;33(2):122–9.
28. Hilari K. The impact of stroke: are people with aphasia different to those without? Disabil Rehabil. 2011;33(3):211–8.
29. Flowers HL, Silver FL, Fang J, Rochon E, Martino R. The incidence, co-occurrence, and predictors of dysphagia, dysarthria, and aphasia after first-ever acute ischemic stroke. J Commun Disord. 2013;46(3):238–48.
30. Schnakers C, Bessou H, Rubi-Fessen I, Hartmann A, Fink GR, Meister I, Giacino JT, Laureys S, Majerus S. Impact of aphasia on consciousness assessment: a cross-sectional study. Neurorehabil Neural Repair. 2015;29(1):41–7.
31. Boehme AK, Martin-Schild S, Marshall RS, Lazar RM. Effect of aphasia on acute stroke outcomes. Neurology. 2016;87(22):2348–54.
32. Flowers HL, AlHarbi MA, Mikulis D, Silver FL, Rochon E, Streiner D, Martino R. MRI-Based Neuroanatomical Predictors of Dysphagia Dysarthria, and Aphasia in Patients with First Acute Ischemic Stroke. Cerebrovasc Dis Extra. 2017;7(1):21–34.
33. González Mc F, Lavados GP, Olavarría IV. Incidence of aphasia in patients experiencing an ischemic stroke. Rev Med Chil. 2017;145(2):194–200.
34. Ginex V, Veronelli L, Vanacore N, Lacorte E, Monti A, Corbo M. Motor recovery in post-stroke patients with aphasia: the role of specific linguistic abilities. Top Stroke Rehabil. 2017;24(6):428–34.
35. Gonzalez R, Rojas M, Ardila A. Alexia and agraphia in Spanish. Int J Lang Commun Disord. 2020;55(6):875–83.
36. García-Rudolph A, García-Molina A, Cegarra B, Opisso E, Saurí J, Tormos JM, Bernabeu M. Subacute ischemic stroke rehabilitation outcomes in working-age adults: The role of aphasia in cognitive functional independence. Top Stroke Rehabil. 2021;28(5):378–89.
37. Xu S, Yan Z, Pan Y, Yang Q, Liu Z, Gao J, Yang Y, Wu Y, Zhang Y, Wang J, et al. Associations between Upper Extremity Motor Function and Aphasia after Stroke: A Multicenter Cross-Sectional Study. Behav Neurol. 2021;2021:9417173.
38. Goldberg EB, Meier EL, Sheppard SM, Breining BL, Hillis AE. Stroke Recurrence and Its Relationship With Language Abilities. J Speech Lang Hear Res. 2021;64(6):2022–37.
39. Grönberg A, Henriksson I, Lindgren A. Accuracy of NIH Stroke Scale for diagnosing aphasia. Acta Neurol Scand. 2021;143(4):375–82.
40. Lin HL, Tsai CF, Liu SP, Muo CH, Chen PC. Association between aphasia and risk of dementia after stroke. J Stroke Cerebrovasc Dis. 2022;31(12):106838.
41. Wilson SM, Entrup JL, Schneck SM, Onuscheck CF, Levy DF, Rahman M, Willey E, Casilio M, Yen M, Brito AC, et al. Recovery from aphasia in the first year after stroke. Brain. 2023;146(3):1021–39.
42. Brogan EL, Kim J, Grimley RS, Wallace SJ, Baker C, Thayabaranathan T, Andrew NE, Kilkenny MF, Godecke E, Rose ML, et al. The Excess Costs of Hospitalization for Acute Stroke in People With Communication Impairment: A Stroke123 Data Linkage Substudy. Arch Phys Med Rehabil. 2023;104(6):942–9.
43. Acharya AB, Wroten M: Broca Aphasia. In: *StatPearls*. Treasure Island (FL): StatPearls PublishingCopyright © 2022, StatPearls Publishing LLC.; 2022.
44. Chuang YC, Liu CC, Yu IC, Tsai YL, Chang ST. Shifting of global aphasia to Wernicke's aphasia in a patient with intact motor function: a case report. BMC Neurol. 2021;21(1):111.
45. Bitan T, Lifshitz A, Breznitz Z, Booth JR. Bidirectional connectivity between hemispheres occurs at multiple levels in language processing but depends on sex. J Neurosci. 2010;30(35):11576–85.
46. Peper JS, Burke SM, Wierenga LM. Sex differences and brain development during puberty and adolescence. Handb Clin Neurol. 2020;175:25–54.
47. Liu LS, Zhao JL, He YL, Song YJ, Zeng XF. The 490th case: arthralgia, amenorrhea, aphasia. Zhonghua Nei Ke Za Zhi. 2021;60(12):1189–92.
48. Xu M, Liang X, Ou J, Li H, Luo YJ, Tan LH. Sex Differences in Functional Brain Networks for Language. Cereb Cortex. 2020;30(3):1528–37.
49. Miao L, Yang S, Yi Y, Tian P, He L. Research on the prediction of longevity from both individual and family perspectives. PLoS ONE. 2022;17(2):e0263992.
50. Purroy F, Vena A, Forné C, de Arce AM, Dávalos A, Fuentes B, Arenillas JF, Krupinski J, Gómez-Choco M, Palomeras E, et al. Age- and Sex-Specific Risk Profiles and In-Hospital Mortality in 13,932 Spanish Stroke Patients. Cerebrovasc Dis. 2019;47(3–4):151–64.
51. Thye M, Mirman D. Relative contributions of lesion location and lesion size to predictions of varied language deficits in post-stroke aphasia. Neuroimage Clin. 2018;20:1129–38.
52. Kasselimis DS, Simos PG, Peppas C, Evdokimidis I, Potagas C. The unbridged gap between clinical diagnosis and contemporary research on aphasia: A short discussion on the validity and clinical utility of taxonomic categories. Brain Lang. 2017;164:63–7.
53. Fridriksson J, den Ouden DB, Hillis AE, Hickok G, Rorden C, Basilakos A, Yourganov G, Bonilha L. Anatomy of aphasia revisited. Brain. 2018;141(3):848–62.
54. Hybbinette H, Schalling E, Plantin J, Nygren-Deboussard C, Schütz M, Östberg P, Lindberg PG. Recovery of Apraxia of Speech and Aphasia in Patients With Hand Motor Impairment After Stroke. Front Neurol. 2021;12:634065.
55. Viglíecca NS. Validity and features of spontaneous speech in acute aphasia as evaluated with the Brief Aphasia Evaluation: is fluent aphasia more severe than nonfluent aphasia? Codas. 2019;31(1):e20180048.
56. Lee S, Na Y, Tae WS, Pyun SB. Clinical and neuroimaging factors associated with aphasia severity in stroke patients: diffusion tensor imaging study. Sci Rep. 2020;10(1):12874.
57. Zhu Z, Deng J, Li M, Qin Y, Li J, Yang Y. Processing speed mediates the relationship between brain structure and semantic fluency in aging. Neurosci Lett. 2022;788:136838.
58. Kaczkurkin AN, Raznahan A, Satterthwaite TD. Sex differences in the developing brain: insights from multimodal neuroimaging. Neuropsychopharmacology. 2019;44(1):71–85.
59. Dreier JP, Lemale CL, Kola V, Friedman A, Schoknecht K. Spreading depolarization is not an epiphenomenon but the principal mechanism of the cytotoxic edema in various gray matter structures of the brain during stroke. Neuropharmacology. 2018;134(Pt B):189–207.
60. Ellis C, Urban S. Age and aphasia: a review of presence, type, recovery and clinical outcomes. Top Stroke Rehabil. 2016;23(6):430–9.
61. Shafto MA, Tyler LK. Language in the aging brain: the network dynamics of cognitive decline and preservation. Science. 2014;346(6209):583–7.
62. Gajardo-Vidal A, Lorca-Puls DL, Team P, Warner H, Pshdary B, Crinion JT, Leff AP, Hope TMH, Geva S, Seghier ML, et al. Damage to Broca's area does not contribute to long-term speech production outcome after stroke. Brain. 2021;144(3):817–32.
63. Hazamy AA, Obermeyer J. Evaluating informative content and global coherence in fluent and non-fluent aphasia. Int J Lang Commun Disord. 2020;55(1):110–20.
64. Minkina I, Martin N, Spencer KA, Kendall DL. Links Between Short-Term Memory and Word Retrieval in Aphasia. Am J Speech Lang Pathol. 2018;27(1s):379–91.
65. Theofilidis A, Karakasi MV, Kevrekidis DP, Pavlidis P, Sofologi M, Trypsiannis G, Nimatoudis J. Gender Differences in Short-term Memory Related to Music Genres. Neuroscience. 2020;448:266–71.
66. Delikishkina E, Lingnau A, Miceli G. Neural correlates of object and action naming practice. Cortex. 2020;131:87–102.
67. Kalita J, Bharadwaz MP, Aditi A. Prevalence, contributing factors, and economic implications of strokes among older adults: a study of North-East India. Sci Rep. 2023;13(1):16880.

Publisher's Note