Relationship between green or black tea consumption and cerebral stroke: A systematic review and meta-analysis

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ABSTRACT

After water, tea is the most popular drink in the world, and its relationship with heart diseases, stroke, and cancer has been always considered by researchers. The aim of the present study is to assess the relationship between green tea or black tea consumption and stroke risk using systematic review and meta-analysis methods. To assess the required resources, PubMed, Scopus, Web of science, Cochrane electronic databases, and the Google Scholar search engine were searched. To assess the study heterogeneity, I2 indexes was used. Data were analyzed using STATA 14 software. *P*<0.05 was considered to be statistically significant. The preventive effect of green tea on cerebral stroke in the case-control studies was more than cohort studies and higher in women than men. Its effect was also lower in people who consume green tea more than 10 years in comparison to people who consume it less than 10 years. Green tea effect was higher in those who consume more than 5 cups/day than those with less than 5 cups/day. The effect of black tea consumption in men and in those who drank less than 5 cups a day or those who drink black tea for 10 years or more was estimated in preventive cohort studies. Green tea has a significant preventive effect on the risk of stroke in different doses and periods of consumption; however, black tea is preventive in a dose of fewer than 5 cups per day and for a period of more than 10 years.

Implication for health policy/practice/research/medical education:
Green tea consumption prevents cerebral stroke. The higher the dosage and duration of black and green tea consumption, the greater the effects of drinking these two types of tea on preventing stroke.

Introduction

Cerebral stroke is a leading cause of death in the world (1), which not only results in disease load but also accompanies severe physical disabilities and other health issues (2). On the other hand, cerebral stroke is mainly preventable via a nutritional regimen (3). After water, tea is the most popular drink in the world (4). The leaves and buds of the *Camellia sinensis* plant are used to make three main types of tea: black tea, oolong tea, and green tea. Of course, 78% of the tea produced in the world is black tea; green tea and oolong tea are in the next ranks (5).

Extensive studies have shown the beneficial health effects of tea. The consumption of green and black tea has been claimed to be associated with a reduction in the risks of cancer, death from pneumonia, cardiovascular disease, and cerebral stroke (6-9). Due to the contradiction in the results of previous studies, the present study was performed using systematic review and meta-analysis methods to assess the relationship between green and black tea consumption with the risk of cerebral stroke.

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Materials and Methods

Study protocol

This meta-analysis was written according to the guidelines of Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) (10). Based on this protocol, all steps of the study were performed by two members of the research team, separately. In the case of contradiction between researchers' reports, the third researcher examined and resolved the problem. The protocol of this study was registered on the international prospective register of systematic reviews (PROSPERO) website (Code: CRD42022328989).

Search strategy

First, PubMed, Cochrane, Scopus, and Web of Science databases were searched using the keywords "Green Tea, Tea, Cerebral stroke, Black Tea" and their medical subject headings (MeSH) equivalents, as well as their combination with operators (AND, OR). The search was performed without time and language restrictions and was updated until 25.08.2021. To complete the search, the first page of the Google Scholar search engine and the sources of the reviewed studies were also searched.

Inclusion criteria

Studies that assessed the relationship between black and green tea use with cerebral stroke.

Exclusion criteria

Not having access to the full text of some studies, studies that assessed the effect of other drinks on cerebral stroke, studies that scored less than 16 from the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist (11), lack of adequate data for analysis, studies that assessed the effects of the green and black tea on other chronic diseases such as cancer.

Qualitative assessment

Two of the researchers independently evaluated the quality of the studies based on the STROBE checklist. The aforementioned checklist has 22 parts. If the total score of this checklist was between 1 and 15 it was considered low quality, between 16 and 30, medium quality, between 31 and 44 high quality. The cut-off point of the STROBE checklist in the present study was 16 (11).

Data extraction

To extract data from the articles, a checklist was prepared by the researchers to provide information, such as the name of the authors, country, type of study, year, number of samples, age group, type of tea, duration of tea consumption, number of men and women, dose of tea consumption, and so on.

Statistical analysis

Odds ratio (OR) was used to examine the effect of green and black tea on cerebral stroke. The logarithm of the OR of each study was used to combine the results of the studies. The heterogeneity of the studies was evaluated using the I^2 index. Data were analyzed with STATA 14 software. The significance level of the tests was considered $P < 0.05$.

Results

First, 425 articles were found via searching in the mentioned databases; from which, 181 repeated studies were deleted using the study title assessment. The abstracts of 244 remaining articles were assessed and 175 articles were deleted based on the exclusion criteria. Forty-eight articles out of 69 were deleted because of data insufficiency or inaccessibility to the full-text manuscript. Finally, 21 articles remained, which had appropriate qualities and entered the meta-analysis (Figure 1). Characteristics of the selected articles are shown in the Table 1.

In Figure 2, OR for green tea in the prevention of cerebral stroke is 0.77 (95% CI: 0.72, 0.82), indicating a statistically significant relationship.

The black tea OR was 0.84 (95% CI: 0.70, 1.01) effective in the prevention of cerebral stroke, though this relationship was not statistically significant (Figure 3). Table 2 shows the effect of green and black tea consumption on cerebral stroke risk separately into different subgroups.

Discussion

According to the results of this meta-analysis, drinking green tea reduces the risk of stroke by 23% and it can be said that drinking green tea prevents stroke. Based on the dosage, the preventive effect of green tea on cerebral stroke was more in the group that consumed 5 cups/day or more than the group that consumed less than 5 cups/day. Based on the duration of use, the preventive effect of green tea on cerebral stroke was higher in those who drank green tea for less than 10 years than those who drank it for 10 years or more. Based on gender, the preventive effect of green tea on cerebral stroke was slightly higher in women than in men.

In the cohort studies, black tea had a preventive effect on cerebral stroke and was statistically significant. The consumption dose in all studies was less than 5 cups/day, in which black tea had a preventive effect on stroke, as well. Based on the duration of use, in those who consumed black tea for 10 years or more, the tea consumption had a cerebral stroke preventive effect on them; however, no statistically significant effect was seen in people who had consumed black tea for less than 10 years. Besides, the preventive effect of black tea consumption on cerebral stroke was significant in men but not significant in women.

The results of a meta-analysis conducted by Arab et al showed that people who drank more than 3 cups of tea per day were 21% less likely to have a stroke compared to people who drank less than 1 cup of tea per day (RR 0.79; 95% CI 0.73, 0.85) (9). According to a study conducted by
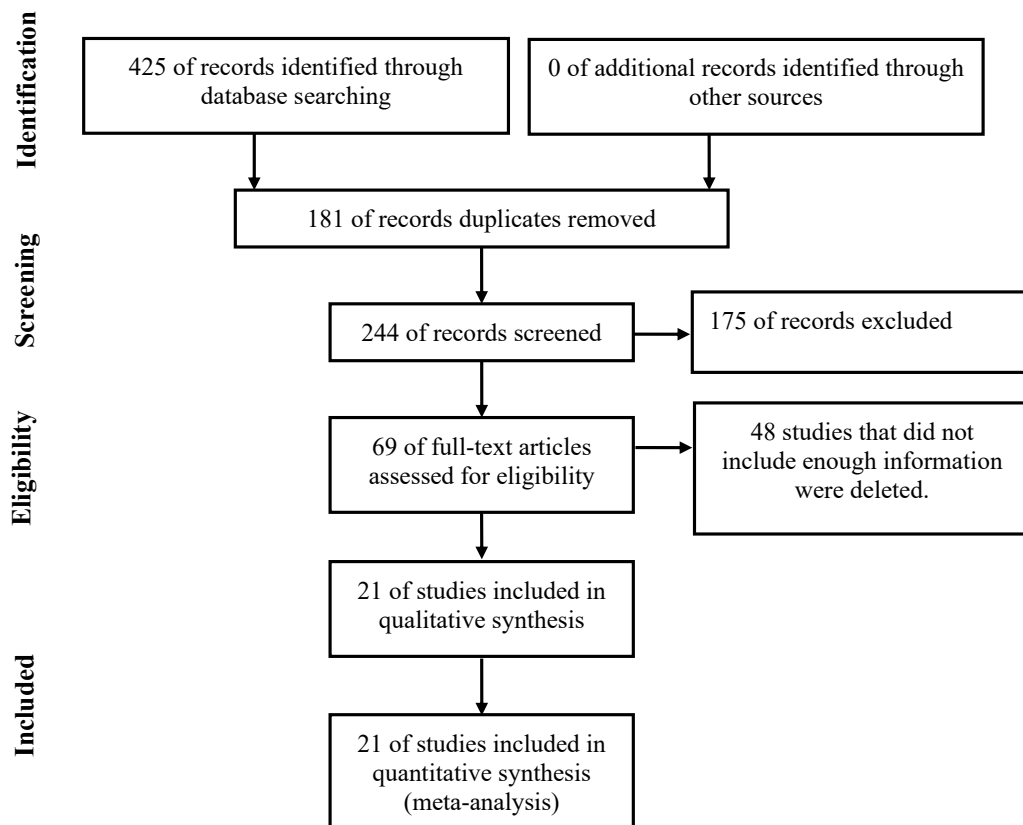
Figure 1. Flowchart of the studies entered into the process of systematic review and meta-analysis.

Abe et al in Japan, individuals who consumed five cups of green tea per day had a lower risk of death from various causes in comparison to those who drank less than one cup of green tea per day. The results showed a hazard ratio (HR) of 0.90 (95% CI: 0.87, 0.94) for men and HR of 0.82 (95% CI: 0.74, 0.90) for women (33).

In the study of Abe et al, the effect of green tea consumption on reducing the risk of cerebral stroke was less in men than in women, which is consistent with the result of our meta-analysis.

A study performed by Wang et al to assess the relationship between drinking tea and the incidence of cerebral stroke in adults in China's Zhejiang province showed that the relative risk of cerebral stroke was 0.79 (95% CI: 0.69-0.89) in participants who did not drink tea weekly in comparison to those consuming 5 g of tea per day (34). Moreover, the results of the meta-analysis performed by Shen et al to determine the relationship between tea consumption and cerebral stroke risk, showed that the consumption of three cups of tea per day was associated with a 13% reduction in the occurrence of cerebral stroke (risk ratio [RR]: 0.87; 95% CI, 0.81–0.94) (35). In the above studies, consuming different doses of tea reduced the risk of cerebral stroke and had a preventive effect. This is consistent with the results of the present meta-analysis.

In the study performed by Tian et al on about half a million Chinese people, the results showed that those who drank tea occasionally (HR: 0.96, 95% CI: 0.94, 0.99), weekly (HR: 0.94, 95% CI: 0.90, 0.98), and daily (HR: 0.92, 95% CI: 0.89, 0.95) were less likely to have a stroke compared to those who did not drink tea, respectively (36). In this study, consuming the higher doses of tea had a greater effect on reducing stroke risk which is consistent with our results.

A meta-analysis performed on 11 prospective studies by Larsson et al to quantitatively assess the relationship between coffee consumption and cerebral stroke risk showed that the relative risk of cerebral stroke in comparison to those who did not consume coffee was 0.86 (95% CI: 0.78, 0.94) for 2 cups per day and 0.93 (95% CI: 0.79, 1.08) for 8 cups per day (37). Based on the results of the current meta-analysis and its comparison with the results of this study, we can see that the effect of green tea consumption in reducing the risk of cerebral stroke is more than coffee consumption.

Study limitations
Some studies provided no details about tea consumption dose or duration. Also, some of the selected studies provided no results based on the different age groups, and the age of participants was reported as an age range and the ranges were overlapped; therefore, we could not have an analysis based on the age groups.

Table 1. Information of the articles entered into the process of systematic review and meta-analysis

First author	Year of publication	Type of study	Place	Population (men or women)	Type of tea	Sample size	Number of people consuming tea	Dosage (cup/ day)	Mean age (year)	Duration of use (year)
Klatsky AL (12)	1993	Cohort	USA	Both	Black	12893	275	≥4	45.2	8
Keli SO (13)	1996	Cohort	Netherlands	Men	Black	552	42	4.7	50-69	15
Thrift AG (14)	1996	Case-Control	Australia	Both	Black	662	331		18-80	
Yochum L (15)	1999	Cohort	USA	Women	Black	34492	131		61.5	10
Sato Y (16)	1999	Cohort	Japan	Women	Green	14360	174	≥5	≥40	4
Hirvonen T (17)	2000	Cohort	Finland	Men	Black	26415	736	≥1	50-69	6
Chen Z (18)	2004	Cross-Sectional	China	Both	Black	14212	160	Over 150 g/mon	35-60	
Kuriyama S (19)	2006	Cohort	Japan	Men	Green	19060	249	≥5	40-79	7
Kuriyama S (19)	2006	Cohort	Japan	Women	Green	21470	223	≥5	40-79	7
Sesso HD (20)	2006	Cohort	USA	Women	Black	37902	256	≥4	53.9	7
Okamoto K (21)	2006	Case-Control	Japan	Both	Green	603	201	≥ 1 times	>2	5
Tanabe N (22)	2008	Cohort	Japan	Men	Green	2087	929	≥ 5	40-89	5
Tanabe N (22)	2008	Cohort	Japan	Men	Green	2087	780	<5	40-89	5
Tanabe N (22)	2008	Cohort	Japan	Women	Green	4271	1944	≥ 5	40-89	5
Tanabe N (22)	2008	Cohort	Japan	Women	Green	4271	1584	<5	40-89	5
Larsson SC (23)	2008	Cohort	Finland	Men	Black	26556	2702	≥2	50-69	13.6
Mineharu Y (24)	2009	Cohort	Japan	Men	Green	34345	3415		40-79	13.1
Mineharu Y (24)	2009	Cohort	Japan	Men	Green	34345	4510	1 to 2	40-79	13.1
Mineharu Y (24)	2009	Cohort	Japan	Men	Green	34345	12151	3 to 5	40-79	13.1
Mineharu Y (24)	2009	Cohort	Japan	Men	Green	34345	8115	≥6	40-79	13.1
Mineharu Y (24)	2009	Cohort	Japan	Women	Green	48310	5017		40-79	13.1
Mineharu Y (24)	2009	Cohort	Japan	Women	Green	48310	5424	1 to 2	40-79	13.1
Mineharu Y (24)	2009	Cohort	Japan	Women	Green	48310	17665	3 to 5	40-79	13.1
Mineharu Y (24)	2009	Cohort	Japan	Women	Green	48310	10288	≥6	40-79	13.1
Liang W (25)	2009	Case-Control	China	Both	Green & Black	838	374		69	

Table 1. Continued

First author	Year of publication	Type of study	Place	Population (men or women)	Type of tea	Sample size	Number of people consuming tea	Dosage (cup/day)	Mean age (year)	Duration of use (year)
Liang W (25)	2009	Case-Control	China	Both	Green & Black	838	374	1 to 2	69	
Liang W (25)	2009	Case-Control	China	Both	Green & Black	838	374	>2	69	
Tomata Y (26)	2012	Cohort	Japan	Both	Green	13988	1316	1 to 2	≥65	3
Tomata Y (26)	2012	Cohort	Japan	Both	Green	13988	1316	3 to 4	≥65	3
Tomata Y (26)	2012	Cohort	Japan	Both	Green	13988	1316	≥ 5	≥65	3
Larsson SC (27)	2013	Cohort	Sweden	Both	Black	74961	4089	≥4		10.2
Kokubo Y (28)	2013	Cohort	Japan	Both	Green	8497	361		45-74	13
Kokubo Y (28)	2013	Cohort	Japan	Both	Green	7490	289		45-74	13
Kokubo Y (28)	2013	Cohort	Japan	Both	Green	8103	346	1	45-74	13
Kokubo Y (28)	2013	Cohort	Japan	Both	Green	17426	672	2 to 3	45-74	13
Kokubo Y (28)	2013	Cohort	Japan	Both	Green	23247	909	≥ 4	45-74	13
Shaikh QN (29)	2014	Cohort	Japan	Both	Green	82369		2 to 4	45-75	13
Lee SM (30)	2015	Case-Control	Korea	Both	Green & Black	1880	940		30-84	
Lee SM (30)	2015	Case-Control	Korea	Both	Green & Black	1880	940		30-84	
Lee SM (30)	2015	Case-Control	Korea	Both	Green & Black	1880	940		30-84	
Lee J (31)	2019	Cohort	Korea	Men	Green	50439	21350	<1	≥40	10
Lee J (31)	2019	Cohort	Korea	Men	Green	50439	7064	1 to <3	≥40	10
Lee J (31)	2019	Cohort	Korea	Men	Green	50439	2224	≥3	≥40	10
Teramoto M (32)	2021	Cohort	Japan	Both	Green	46213	9253		40-79	18.5
Teramoto M (32)	2021	Cohort	Japan	Both	Green	46213	9253	1 to 2	40-79	18.5
Teramoto M (32)	2021	Cohort	Japan	Both	Green	46213	9253	3 to 4	40-79	18.5
Teramoto M (32)	2021	Cohort	Japan	Both	Green	46213	9253	5 to 6	40-79	18.5
Teramoto M (32)	2021	Cohort	Japan	Both	Green	46213	9253	≥7	40-79	18.5

Table 2. The effect of drinking green tea and black tea on the risk of cerebral stroke based on the variables of study type, dosage, duration of use, gender and country of residence

| Type of tea	Subgroups		Odds ratio (95% confidence interval)	I² (%)	P value	Effect of green tea or black tea on cerebral stroke (Protective or risk factor)	Was this relationship significant?
Green tea	Type of study	Case-Control	0.52(95% CI :0.38, 0.71)	75.3	<0.001	Protective	Yes
		Cohort	0.82(95% CI :0.77, 0.86)	53.9	<0.001	Protective	Yes
		Total	0.77(95% CI :0.72, 0.82)	65.5	<0.001	Protective	Yes
	Dosage (cup/day)	<5	0.80(95% CI :0.72, 0.89)	65.6	<0.001	Protective	Yes
		≥5	0.70(95% CI :0.61, 0.81)	55.6	0.016	Protective	Yes
	Duration of use (y)	<10	0.73(95% CI :0.64, 0.82)	59	0.007	Protective	Yes
		≥10	0.86(95% CI :0.81, 0.91)	37.5	0.040	Protective	Yes
	Sex	Men	0.78(95% CI :0.64, 0.95)	59.9	0.008	Protective	Yes
		Women	0.77(95% CI :0.69, 0.87)	4.2	0.398	Protective	Yes
	Country	Japan	0.82(95% CI :0.77, 0.87)	56.5	<0.001	Protective	Yes
		Korea	0.76(95% CI :0.69, 0.84)	0	0.495	Protective	Yes
		China	0.31(95% CI :0.20, 0.48)	41.5	0.163	Protective	Yes
Black tea	Type of study	Case-Control	1.07(95% CI :0.72, 1.59)	69	0.004	Risk factor	No
		Cohort	0.77(95% CI :0.68, 0.86)	7.9	0.368	Protective	Yes
		Total	0.84(95% CI :0.70, 1.01)	61.5	0.001	Protective	No
	Dosage (cup/day)	<5	0.47(95% CI :0.29, 0.75)	26.5	0.243	Protective	Yes
		≥5	Not report	Not report	Not report	Not report	Not report
	Duration of use (y)	<10	0.84(95% CI :0.68, 1.04)	0	0.811	Protective	No
		≥10	0.72(95% CI :0.58, 0.88)	40.6	0.168	Protective	Yes
	Sex	Men	0.62(95% CI :0.41, 0.95)	57.1	0.097	Protective	Yes
		Women	0.86(95% CI :0.61, 1.21)	0	0.575	Protective	No
	Country	Sweden	0.79(95% CI :0.62, 1)	---	---	Protective	No
		Korea	1.28(95% CI :0.91, 1.81)	0	0.480	Risk factor	No
		China	0.66(95% CI :0.33, 1.30)	80.3	0.002	Protective	No
		Finland	0.75(95% CI :0.64, 0.87)	0	0.869	Protective	Yes
		USA	0.85(95% CI :0.68, 1.05)	0	0.851	Protective	No
		Netherlands	0.34(95% CI :0.17, 0.68)	---	---	Protective	Yes
		Australia	1.51(95% CI :0.89, 2.56)	---	---	Risk factor	No
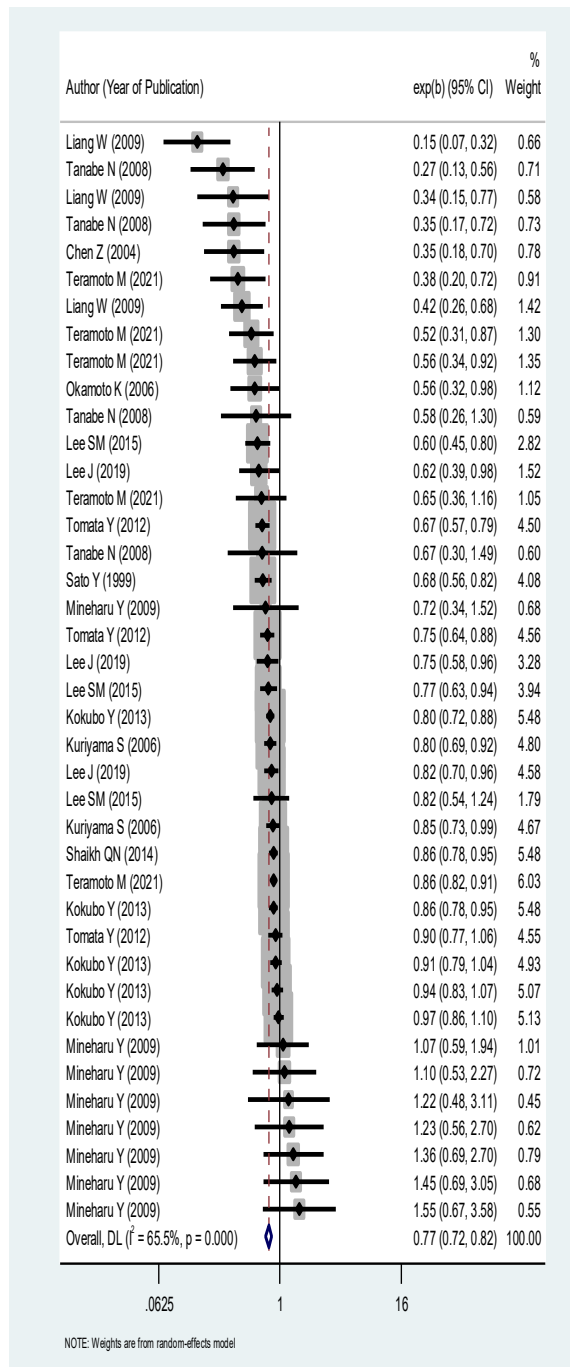
Figure 2. The forest plot showing the relationship between green tea consumption and cerebral stroke risk with its 95% confidence interval. The length of each segment of the line indicates the confidence interval reported by that study and the middle point of each segment of the line indicates the result reported by the same study. The rhombus symbol shows the final result of the combination of the studies.

Figure 3. The forest plot shows the relationship between black tea consumption and cerebral stroke risk with its 95% confidence interval. The length of each segment of the line indicates the confidence interval reported by that study and the middle point of each segment of the line indicates the result reported by the same study. The rhombus symbol shows the final result of the combination of the studies.

seen only in cohort studies, and this relationship was not significant in case-control studies. Hence, more studies are needed for a more reliable conclusion.

Authors' contributions
Data curation: Moloud Fakhri, Tayebe Jamshidbeigi.
Formal analysis: Diana Sarokhani.
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Project administration: Sam Mirfendereski.
Resources: Ayda Hasanpour Dehkordi.
Software: Diana Sarokhani.
Writing–original draft: All authors.
Writing–review & editing: All authors.

Conflict of interests
The authors declare no competing interests.

Data availability statement
The data used in this manuscript is openly available.

Ethical considerations
Ethical issues (including plagiarism, data fabrication, double publication, etc) have been completely observed by the authors.

Conclusion
This study showed that drinking green tea reduced the risk of stroke by 23% and it could be said that drinking green tea prevents stroke. The higher the dose of green tea and the shorter its duration, the better the result and the greater the effect of green tea in preventing the risk of stroke. But the beneficial effect of black tea in preventing stroke was
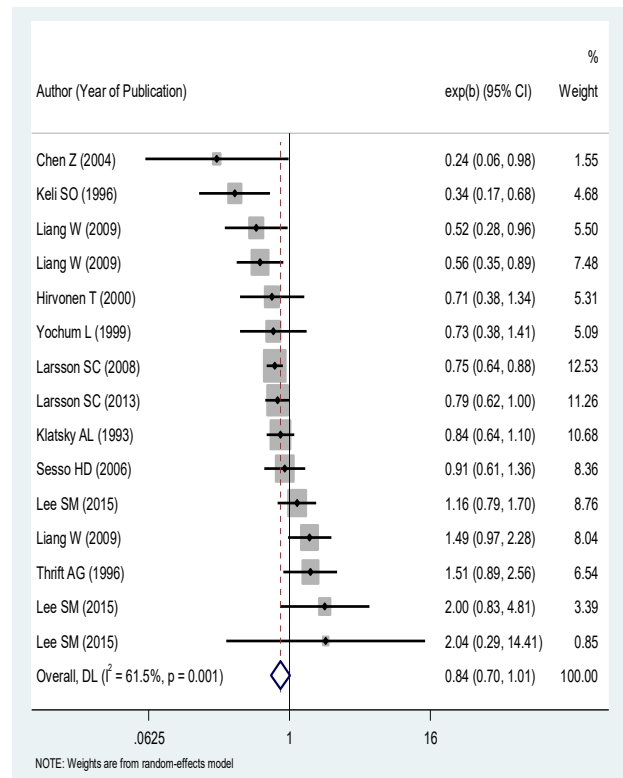
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