SYSTEMATIC REVIEW   **Open Access**

A systematic review and meta-analysis of chronic obstructive pulmonary disease in asia: risk factors for readmission and readmission rate

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Abstract

Background Patients with chronic obstructive pulmonary disease (COPD) often require hospital readmission because of exacerbation of their condition. These frequent exacerbations reduce quality of life, work performance, and emotional health. However, few studies have investigated the risk factors for readmission and readmission rates in Asian patients with COPD. We conducted a systematic review to identify and understand the major risk factors for readmission in patients with COPD in Asia and the readmission rate.

Method We searched PubMed, MEDLINE, Embase, China National Knowledge Infrastructure, Wanfang Data Knowledge Service Platform, and China Biomedical Literature Database from database inception to September 2023 to identify studies on the readmission rate and risk factors for COPD in Asian patients. Chinese search terms included "COPD," "chronic obstructive pulmonary disease," "risk factors," "recurrence," "readmission," and "acute exacerbation." English search terms included "chronic obstructive pulmonary disease," "COPD," "lung emphysema," "hospital admission," "patient readmission," and "readmission." We extracted first author, publication year, research area, sample size, sex, risk factors, and readmission rates. The included studies' quality was evaluated using the Agency of Healthcare Research and Quality. Meta-synthesis was conducted on readmission rates and risk factors for readmission. Subgroups were formed by age, research area, sample size, and research type, and meta-regression analysis was conducted on the 30-day, 90-day, and 365-day readmission rates of patients to determine the source of heterogeneity. Finally, the results' robustness was evaluated using sensitivity analysis. Begg and Egger tests were used to evaluate publication bias.

Results Meta-analysis of 44 studies, with 169,255 participants, indicated that risk factors for COPD readmission in Asia included: history of multiple hospital admissions, ≥ 3 comorbidities, male sex, ratio of eosinophils percentage ≥ 2%, body mass index < 18.5, smoking history, pulmonary heart disease comorbidity, COPD assessment test score > 20, nutritional disorder, Neutrophil-to-Lymphocyte ratio > 7, and FEV1 < 50. The 30-, 90-, and 365-day readmission rates of patients were 19%, 31%, and 42%, respectively.

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Conclusions Patients with COPD in Asia generally have high readmission rates and different risk factors. To reduce healthcare, economic, and social burdens, interventions should address major risk factors, early prevention, and screening.

Keywords Asia, Chronic obstructive pulmonary disease, Risk factor, Readmission rate, Meta-analysis

Introduction

Chronic obstructive pulmonary disease (COPD) is characterized by progressive airflow restriction and decreased lung function. According to the Global Burden of Disease Study [1], approximately 600 million people worldwide have COPD. Meanwhile, mortality attributed to COPD has shown an increasing trend and has become the third leading cause of death globally. The frequent exacerbation of COPD can greatly reduce quality of life and seriously affect the work performance and emotional health of patients. Moreover, repeated acute COPD exacerbations are closely associated with increased mortality. An earlier study [2] reported that a new exacerbation of COPD significantly increases the risk of subsequent exacerbations; specifically, patients were 25 times more likely to be readmitted after their 10th COPD hospital admission than after their first COPD admission.Patients with COPD may be hospitalized repeatedly owing to worsening respiratory symptoms, which poses a significant economic and social burden on medical resources and society as a whole. Currently, the top ten countries with the highest number of patients with COPD (China, India, Indonesia, the United States, Bangladesh, Japan, Pakistan, Russia, Vietnam, and Germany) have reported a total of 25.54 billion cases (65.2% of the world's total). Asia accounts for a large proportion of COPD cases [3], but there is currently a lack of research on the readmission rate and risk factors for COPD in Asia. Although understanding of the risk factors for COPD readmission has improved, existing investigations have primarily focused on populations in Europe and North America [4], while research targeting Asian populations is rare. In this context, this study systematically retrieved related studies on the risk factors for COPD and readmission rates in Asia to provide insights to help inform clinical interventions.

Material and methods

Literature Search Strategy

A systematic literature search was conducted using PubMed, Medline, Embase, China National Knowledge Infrastructure, Wanfang Data, and SinoMed databases from inception to September 2023 to identify studies focusing on the readmission rate and risk factors for COPD in Asia. The search strategy adopted a combination of subjects and free words. The Chinese search terms included "COPD," "chronic obstructive pulmonary disease," "risk factors," "recurrence," "readmission," and "acute exacerbation"; the English search terms included "chronic obstructive pulmonary disease," "COPD," "lung emphysema," "hospital admission," "patient readmission," and "readmission." Taking MEDLINE as an example, the specific search strategy is presented in Table 1.

Inclusion and exclusion criteria

The inclusion criteria were (1) Studies with COPD as the primary diagnosis for readmission and (2) Studies focusing on the readmission rate, risk factors, and predictive factors for COPD. The exclusion criteria were (1) Conference abstracts, editorial reports and letters, master's dissertations or comments, and duplicate publications; (2) Studies describing the implementation of interventions or programs beyond routine care; and (3) Studies conducted outside Asia.

Table 1 Medline search strategies

	Search Strategies
#1	AB chronic obstructive pulmonary diseas OR COPD OR bronchitis OR emphysema OR lung emphysema OR chronic obstructive lung diseas OR chronic obstructive airway disease
#2	AB hospitalization OR AB patient admission OR AB bronchitis OR AB patient admission OR AB hospitalisation OR AB hospitalization OR AB patient admission OR AB patient transfe OR AB voluntary admission OR AB hospital stay OR hospital admission
#3	AB patient readmission OR AB readmission OR AB re- admission OR AB epeat admission OR AB multiple admission OR AB rehospitalisation OR AB hospitalization OR AB re-hospitalisation
#4	#2 OR #3
#5	#4 AND #1

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Literature screening and data extraction

Two researchers independently screened the studies retrieved from a preliminary literature search based on the inclusion and exclusion criteria and extracted the desired data. Subsequently, a cross-check was conducted. Any disputes were resolved by consulting a third researcher. During the literature search, unrelated studies were excluded by examining titles and abstracts. Subsequently, full texts of the remaining studies were reviewed to determine the final inclusion criteria. The main data extracted included the first author, year of publication, region of research, sample size, gender ratio, risk factors, and readmission rate.

Quality assessment

The risk of bias of each study was assessed based on the cross-sectional study evaluation criteria recommended by the Agency of Healthcare Research and Quality in the U.S., which consists of 11 items. Each item was answered as "yes" (score 1), "no" (score 0), or "unclear" (score 0), resulting in a maximum score of 11 points. A study was rated as low quality if it received a score of 0–3, moderate quality if it received a score of 4–7, and high quality if it received a score of 8–11.

Statistical method

In this study, meta-analysis was conducted using Stata 17.0, and the effect statistics were set as the readmission rate and 95% CI. Heterogeneity of the research results was determined using I^2. A low level of heterogeneity was indicated if $I^2 < 50\%$ and $P > 0.10$, and a fixed-effects model was used for meta-analysis; otherwise, a random-effects model was used. Subsequently, parallel meta-regression to find sources of heterogeneity in the readmission rate of patients with COPD was conducted according to age, study area, sample size, and research subgroups, at 30, 90, and 365 days. $P < 0.05$ was considered statistically significant, and sensitivity analysis was performed to determine whether the results of COPD readmission rates in Asia were robust. Finally, the publication bias of the included studies was assessed using the Begg and Egger tests.

Results

Literature screening

A preliminary literature search of the Chinese and English databases yielded 29,840 relevant articles. After screening the titles and abstracts, 400 studies met our criteria for further review. After full-text review and quality assessment, 44 articles were included in our meta-analysis. A literature screening flowchart is shown in Fig. 1.

Study characteristics and risk of bias assessment

The 44 studies [5–48] included a total sample size of 169,255 individuals. The basic study characteristics and risk-of-bias assessment results are summarized in Table 2.

Meta-analysis results

Meta-analysis results for risk factors for COPD readmission

Thirty-nine studies reported the risk factors for COPD readmission. The meta-analysis identified a total of 11 risk factors with statistical significance, namely history of ≥ 2 hospital admissions (OR: 2.8; 95% CI: 1.96–4.27; $P < 0.001$), ≥ 3 comorbidities (OR: 1.17; 95% CI: 1.05–1.31; $P = 0.005$), male sex (OR: 1.56; 95% CI: 1.25–1.94; $P < 0.001$), ratio of eosinophils percentage (EOS%) ≥ 2% (OR: 3.01; 95% CI: 1.87, 4.85; $P < 0.001$), body mass index (BMI) < 18.5 (OR: 3.51; 95% CI: 2.24–5.0; $P < 0.001$), smoking history (OR: 1.9; 95% CI: 1.37–2.64; $P < 0.001$), pulmonary heart disease comorbidity (OR: 2.71; 95% CI: 1.82–4.02; $P < 0.001$), COPD assessment test (CAT) score > 20 (OR: 1.43; 95% CI: 1.15–17.78; $P = 0.001$), nutritional disorder (OR: 2.93; 95% CI: 2.17–3.96; $P < 0.001$), Neutrophil-to-Lymphocyte ratio (NLR) > 7 (OR: 1.93; 95% CI: 1.35–2.77; $P < 0.001$), and FEV1 < 50 (OR: 2.43; 95% CI: 1.6–3.67; $P < 0.001$). In contrast, a high education level was identified as a protective factor (OR: 0.73; 95% CI: 0.59–0.89; $P < 0.05$). Additionally, comorbidities of diabetes, coronary heart disease, congestive heart failure, and PaCO2 ≥ 50 had no statistical significance ($P > 0.05$). The details are presented in Table 3.

Readmission rate for persons with COPD in Asia

In 17 studies, the 30-day readmission rate for persons with COPD ranged from 6% to 39%; in 10 studies, the 90-day readmission rate ranged from 16% to 61%; and in 11 studies, the 365-day readmission rate ranged from 29% to 53%. The combined 30-, 90-, and 365-day readmission rates were 19% (95% CI: 0.15–0.22; $I^2 = 99.8\%$), 31% (95% CI: 0.19–0.43; $I^2 = 98.3\%$), and 42% (95% CI: 0.37–0.47; $I^2 = 85.2\%$), respectively (Figs. 2, 3, 4).

Sensitivity analysis

Sensitivity analysis was performed by removing one study at a time. No abnormal values were found in the

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Records identified through
database searching(n=29873)

Additional records identified
through other sources(n=0)

Records after duplicates
removed(n=29838)

Records excluded by title/abstract
Screening(n=29438)

Records obtained through preliminary
screening(n=400)

Full-text articles excluded with
reasons(n=356)
1) Not analysing risk factors and
    readmission rate (n=118)
2) Intervention measures were taken
    in the articles(n=52)
3) Conference abstracts, editorial
    reports and letters, master's
    dissertations or comments(n=76)
4) Studies conducted outside of
    Asia(n=107)
5) Unable to obtain full text(n=3)

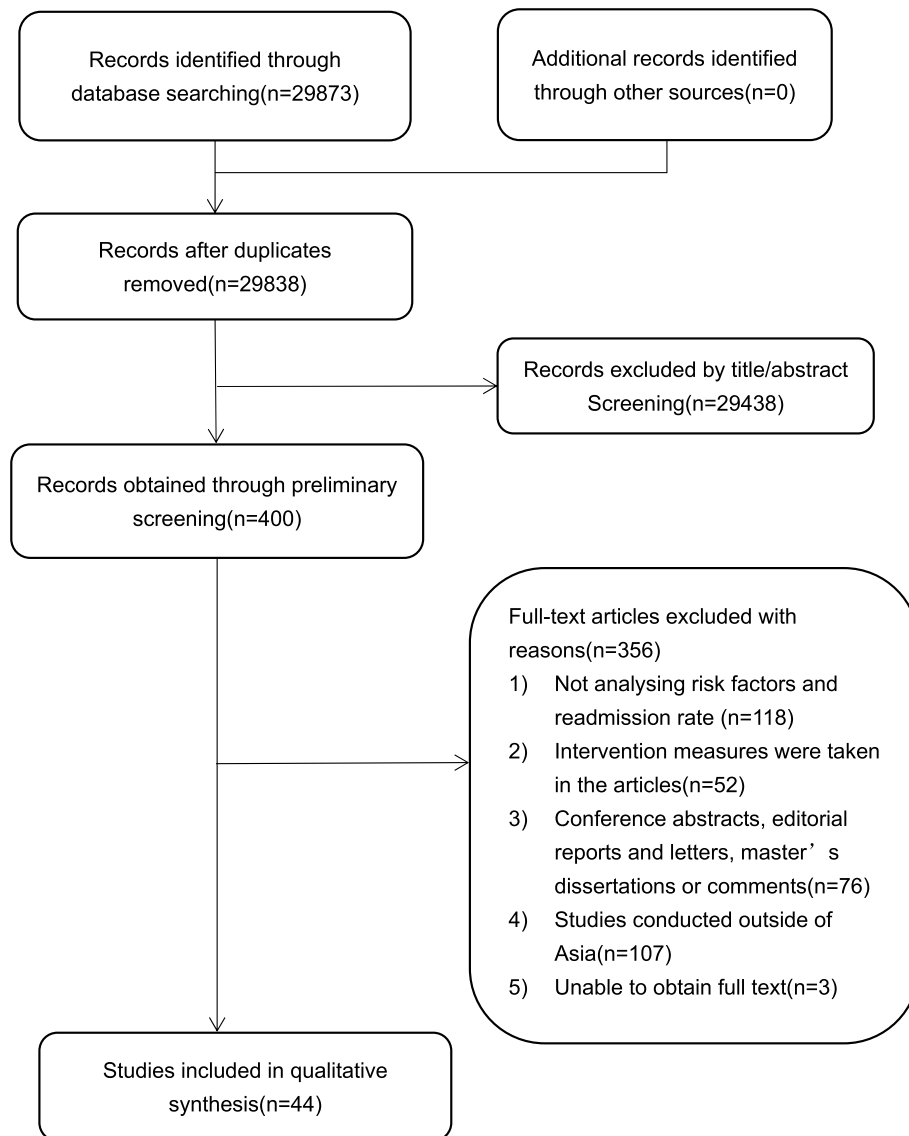Studies included in qualitative
synthesis(n=44)

Fig. 1 Literature screening flow and results

30-, 90-, and 365-day readmission rates of Asian patients with COPD, indicating that the meta-analysis results were robust and reliable (Figs. 5, 6, 7).

Subgroup analyses

Owing to the high heterogeneity among the included studies, subgroup analyses were conducted by age, region of research, sample size, investigation area, and study type. As the level of heterogeneity remained significant in the subgroups, a random-effects model was used for the meta-analysis. The results showed that: (1) Regarding the region of research, the 30- and 90-day readmission rates of patients with COPD in China were 20% and 26%, respectively, and the 365-day readmission rates in southern and northern China were 39% and 45%, respectively. (2) Regarding study type, the 30-, 90-, and 365-day readmission rates were 18%, 38%, and 40%, respectively, in retrospective studies, and 22%, 23%, and 43%, respectively, in prospective studies. (3) Regarding sample size, the 30-, 90-, and 365-day readmission rates in studies with a sample size of 0–499 were 21%, 27%, and 43%, respectively, whereas the 30-day readmission rates in studies with a sample size of 500–999, 1000–10000, and ≥10000 were 14%, 20%, and 18%, respectively. (4) Regarding age, the 30-, 90-, and 365-day readmission rates

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Table 2 Basic characteristics of the included studies and the results of the risk of bias evaluation

References	Year	Country	Sample size	Age (years)	Sex(male %)	Bias risk score
Cao Zhenying	2005	Singapore	196	72	85%	7
Chen Yiping	2020	Guangdong,China	92	72.19 ± 8.45	66.30%	5
Ding Ruiyang	2022	AnHui,China	330	67.41±16.98	70.30%	5
He Bing	2020	Sichuan,China	174	72.8±9.0	51.70%	5
Hu Hao	2023	Chongqing,China	141	69.03±8.7	76.50%	6
Linling	2020	AnHui,China	187	70.79±7.74	84.50%	4
Liu Ying	2023	Shanghai,China	208	72.92±2.82	78.30%	4
Nan Haoyu	2013	Shanxi,China	127	67±9	93.70%	6
Wan Lei	2023	Nanchang,China	121	75	76.80%	7
Wang Jing	2019	Jiangsu,china	197	73.6±5.7	76.10%	6
Yan Yusheng	2014	Changsha,China	484	68.12±5.21	62.60%	8
Yang Liqing	2022	Sichuan,China	285	71.15	69.80%	8
Yin Jingjing	2023	Beijing, China	143	72.2±6.0	75.50%	6
Zhou Yinchuan	2022	Guangdong, China	286	69.3±10.1	27.60%	6
Zhang Rui	2021	Ningxia, China	1120	60~96	61%	7
Bao Yiqin	2022	AnHui,China	224	68.35±11.04	79.90%	6
Zhang Jing	2014	Beijing, China	137	72~81	63.60%	8
Wu Jianguang	2019	Guangdong, China	125	67.5 ±5.5	65.60%	5
Feng Xiaoyi	2022	Sichuan,China	496	72.2±9.6	73.60%	7
Ye Jiani	2023	Zhejiang china	283	74.88±8.39	78.70%	5
Zhang Guimei	2022	Kunming, China	414	68.52 ±9.344	84.80%	4
Zhou Mei	2022	Henan, China	143	73.08±6.44	20.97%	5
Sana	2017	Malaysia	81	72	97.53%	6
Frank	2011	Hong Kong, China	65497	76.81±9.59	77%	5
ChunC	2014	Beijing, China	135	60-74	88.10%	7
LLC	2021	Nanjing, China	636	70.82 ± 9.88	66.82	5
Yea-JyhC	2006	Taiwan, China	145	72.17 ± 9.97	73.10%	5
JuwhanC	2018	Korea	704	73.9±9.6	69.80%	5
Aylin	2021	Turkey	300	74.87 ± 9.06	71.60%	6
Tadahiro	2019	Japan	44,929	70–83	81%	4
MiHyun	2010	Korea	77	69.2±9.4	83.10%	5
Tae Wan	2021	Korea	4867	NI	69%	6
JCL	2022	Beijing, China	20808	74.7 ± 10.7	80.60%	7
JYL	2023	Jiangsu,china	303	78.04 ± 8.04	79.20%	6
Meng	2023	Macao, China	782	80.73	69%	5
JL	2014	Zhejiang china	692	72.95±8.399	78.60%	5
HYL	2022	Ningxia, China	1120	NI	60.98%	6
Junnan	2021	Chongqing,China	123	71.1±9.6	73.20%	7
Michal	2022	Israel	1203	70.6±11.0	63%	4
Ryusuke	2016	Japan	110	68.0±6.4	70.90%	7
XW	2018	Xi'an, China	286	68.44±10.1	77.90%	5
TTX	2022	Nanjing, China	465	70.1±9.3	88%	7
TY	2023	China	4978	66.2 ± 8.9	79.50%	7
Yong	2020	Korea	15101	73.5 ± 9.69	74.60%	5

NI No information

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Table 3 Meta analysis of risk factors for readmission of COPD

Risk factors	Number of studies	OR (95% CI)	P
history of multiple hospital admissions (≥2 times vs 0 or 1)	14	2.80 (1.96, 4.27)	0.000
male	5	1.56 (1.25, 1.94)	0.000
number of comorbidities (≥3 vs 1 or 2)	4	1.17 (1.05, 1.31)	0.005
PaCO2 (≥50 vs <50)	5	1.10 (0.98,1.23)	0.111
EOS% (≥2% vs <2%)	5	3.01 (1.87,4.85)	0.000
BMI<18.5	3	3.51 (2.24,5.0)	0.000
comorbidity with diabetes	2	1.55 (0.67,3.59)	0.307
smoking history	2	1.45 (1.14, 1.83)	0.002
comorbidity with pulmonary heart disease	3	2.71 (1.82,4.02)	0.000
comorbidity with coronary heart disease	2	1.40 (0.81,2.42)	0.229
comorbidity with congestive heart failure	2	1.39 (0.74,2.58)	0.304
CAT (>20 vs <20)	6	3.17 (1.32,7.56)	0.009
nutritional disorder	3	2.93 (2.17, 3.96)	0.000
NLR (>7 vs <7)	2	1.93 (1.35, 2.77)	0.000
high education level	2	0.73 (0.59, 0.89)	0.002
FEV1 (<50 vs >50)	3	2.43 (1.60, 3.67)	0.000

EOS Ratio of eosinophils, *CAT* COPD Assessment Test, *NLR* Neutrophil-to-Lymphocyte Ratio, *OR* Odds Ratio

of patients with COPD aged 60–69 years were 21%, 32%, and 45%, respectively; the 30-, 90-, and 365-day readmission rates of patients with COPD aged 70–79 years were 21%, 32%, and 45%, respectively; and the 30-day readmission rate of patients with COPD aged ≥80 years was 6%. Meta-regression analysis was performed to further explore the sources of heterogeneity. There were differences in the 30-day readmission rate in the age subgroup, the 90-day readmission rate in the research and sample size subgroups, and the 365-day readmission rate in the age subgroup (Table 4).

Publication bias
Funnel plots were drawn for 30-, 90-, and 365-day COPD readmission rates in Asia. The symmetry of the distribution was generally poor. However, the results of the Egger and Begg tests suggested no significant publication bias in the 30-day ($P = 0.528$ and $P = 0.967$), 90-day ($P = 0.123$ and $P = 0.474$), and 365-day ($P = 0.075$ and $P = 0.436$) readmission rates (Figs. 8, 9, 10).

Discussion
The meta-analysis results of this study showed that among patients with COPD, readmission rates at 30, 90, and 365 days were 19%, 31%, and 42%, respectively. In a systematic review, Alqahtani et al [4] found that patients with COPD 30 and 90 days following the acute aggravation period had readmission rates of 8.8%-26%, 17.5%-39%, respectively. The results are similar to those of the current study, but the prior study considered only three areas in Asia and did not execute a meta-analysis of readmission rate on different days. The readmission rate range is relatively wide and rather poor, owing to acute exacerbation readmission in patients with COPD in Asia. Another review [49] of 42 studies, including three from Asia, found that patients with COPD had readmission rates 30, 60, 90, 180, and 365 days following acute aggravation of 11%, 17%, 17%, 30%, and 37%, respectively. This may [49] be contrasted with a study of Asian patients with COPD at 30, 90, and 365 days; the readmission rate was higher, showing that in patients with COPD in Asia, exacerbations repeatedly occur; this should not be ignored by Asian hospitals.

Regarding risk factors of readmission, Ruan et al [49] found that male sex, number of hospitalizations in the previous year, length of hospital stay, heart failure, tumor and other cancers, and diabetes and its complications were risk factors for readmission in patients with COPD, while obesity was a protective factor. Visible risk factors include male sex, history of hospitalization, and lower BMI. The difference is in the impact of comorbidities: This study found that only when the number of comorbidities was ≥3 was there a risk factor; the presence of a single disease was not a risk factor, but cor pulmonale was one risk factor. We believe that acute exacerbation of COPD is a complex process that may be affected by many factors, including comorbidities, environmental factors, and lifestyle. When a certain number of complications is exceeded, such
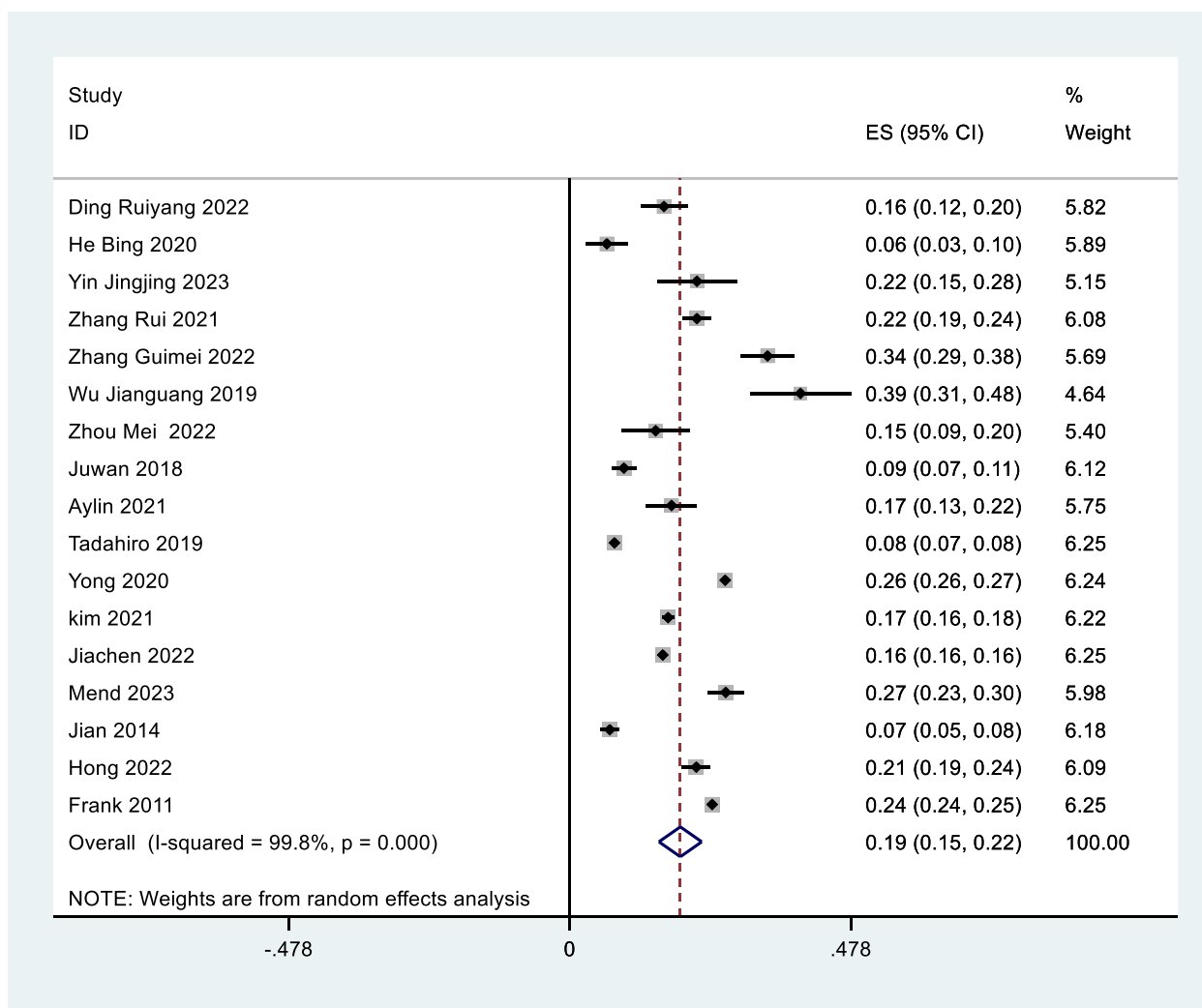
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Fig. 2 Forest plot of 30 day readmission rate for COPD

as three or higher, there may be a cumulative effect; namely, the combination of complications in patients with multiple diseases increases the risk of exacerbations. This effect may not be a simple linear relationship but rather a result of the interaction of multiple factors. Cor pulmonale may directly affect heart function and, thus, have a direct impact on the acute exacerbation of COPD. Even if the number of comorbidities is low, the presence of cor pulmonale may significantly increase the risk of acute exacerbations.

The reason men are exposed to a higher risk of COPD than women may be related to higher smoking rates in men. Smoking is an important factor in the occurrence, development, and readmission of patients with COPD. This may be because tobacco can induce systemic inflammation, impair endothelial function,

and exert oxidative stress on the human body, which have sustained impacts on lung structure, respiratory immune function, and lung function. We also found that comorbidity with pulmonary heart disease and ≥ 3 comorbidities were closely related to COPD readmission. This is consistent with Chen et al. [41], who indicated that the average probability of COPD readmission within one month after discharge for patients with cardiovascular disease, diabetes, or bronchial asthma was nearly twice as high as that for patients without comorbidities. Spece et al. [50] found that for every one percent increase in the comorbidity index, the risk of readmission or death increased by 24%. Furthermore, malnutrition is an important factor that affects prognosis and is associated with a significantly increased risk of 30-day readmission. Consistently,
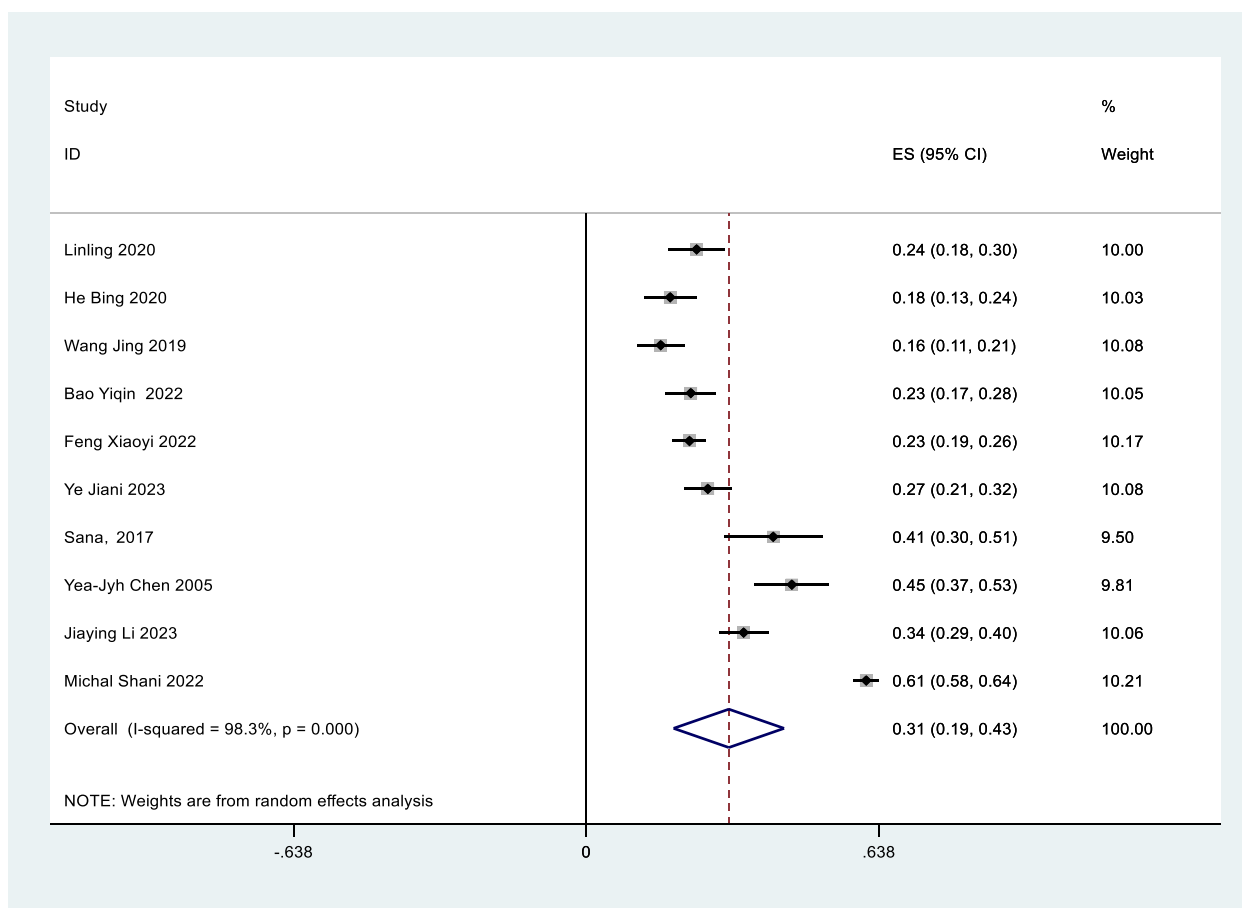
Study		%
ID	ES (95% CI)	Weight

Linling 2020	0.24 (0.18, 0.30)	10.00
He Bing 2020	0.18 (0.13, 0.24)	10.03
Wang Jing 2019	0.16 (0.11, 0.21)	10.08
Bao Yiqin 2022	0.23 (0.17, 0.28)	10.05
Feng Xiaoyi 2022	0.23 (0.19, 0.26)	10.17
Ye Jiani 2023	0.27 (0.21, 0.32)	10.08
Sana, 2017	0.41 (0.30, 0.51)	9.50
Yea-Jyh Chen 2005	0.45 (0.37, 0.53)	9.81
Jiaying Li 2023	0.34 (0.29, 0.40)	10.06
Michal Shani 2022	0.61 (0.58, 0.64)	10.21
Overall (I-squared = 98.3%, p = 0.000)	0.31 (0.19, 0.43)	100.00

NOTE: Weights are from random effects analysis

-.638   0   .638

Fig. 3 Forest plot of 90 day readmission rate for COPD

BMI < 18.5, was also indicated as a risk factor for COPD readmission. Therefore, patients with COPD should maintain good nutritional status to reduce the risk of readmission. Moreover, it has been reported that multiple acute hospital admissions due to acute COPD attacks in the previous year is a key risk factor for readmission. Two earlier studies [51, 52] found that the risk of 30-day readmission in patients with COPD who had a history of repeated deterioration and those who had a history of hospital admission in the previous year was significantly increased by 53–54% and 60–64%, respectively. Additionally, we also found that NLR > 7, EOS% ≥ 2%, and FEV1 < 50 were risk factors for COPD readmission in Asia, which may be related to worse lung conditions and poor treatment for severe pulmonary infections.

This meta-analysis included 44 studies. The results showed that the 30-, 90-, and 365-day readmission rates of patients with COPD in Asia were 19%, 31%, and 42%, respectively. Alqahtani et al. [4] reported that

the incidence of readmission during acute COPD was 2.6–82.2% at 30 days, 11.8–44.8% at 31–90 days, 17.9–63.0% at 180 days, and 25.0–87.0% at 365 days after discharge. These data are consistent with our results. In the age subgroup analysis, we noticed that the age group of 60–69 years was associated with the highest 30-, 90-, and 365-day readmission rates, while the age groups of 70–79 years and ≥ 80 years had lower readmission rates. This may be because older patients have more serious underlying diseases and may die outside the hospital (such as at home or in a nursing home), resulting in no readmission. Further, subgroup differences were detected in the regression of 30- and 365-day readmission rates ($P < 0.05$), indicating that age may contribute to differences in readmission rates. However, no heterogeneity was detected in the 365-day readmission rate, which may be explained by the availability of age data. Specifically, some age data were presented as median and mean deviations, resulting in a large and uneven age distribution, which may have
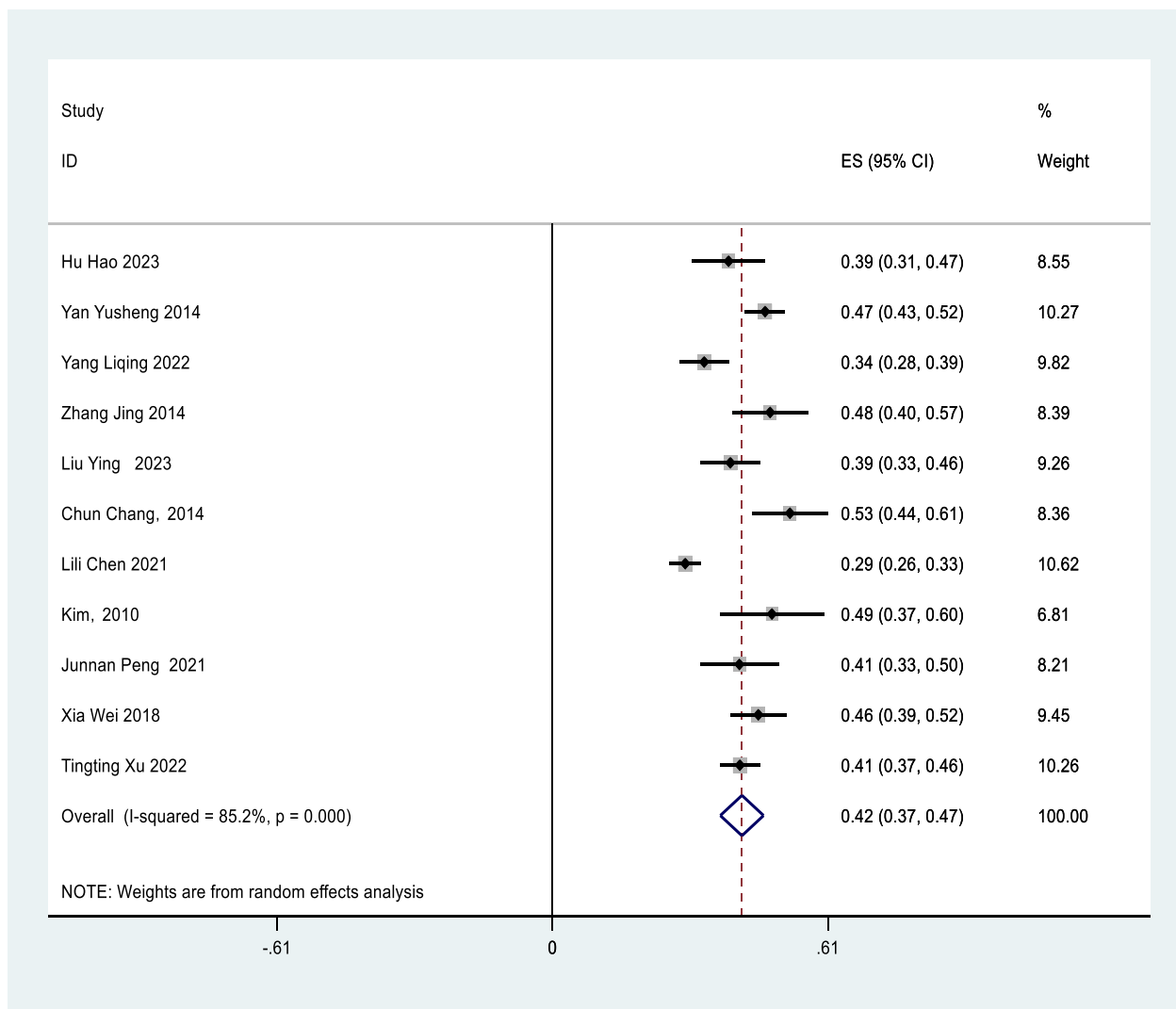
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Fig. 4 Forest plot of 365 day readmission rate for COPD in Asia

affected our results to some extent. In the subgroup analysis, we found that prospective studies had higher 30- and 365-day readmission rates than retrospective studies. This is probably because the results of the retrospective studies were primarily derived from medical records and related databases and were subject to common limitations of retrospective designs, including selection bias and misclassification bias, leading to lower readmission rates. However, in the regression analysis, no subgroup differences were found according to study type for 30-, 90-, and 365-day readmission rates ($P > 0.05$), indicating that study type may not be a source of heterogeneity. However, this must be confirmed in future studies. In the sample size subgroup

analysis, we found that studies with a sample size of 0–499 had the highest 30-day readmission rate, while the 30-day readmission rates of studies with a sample size of 1000–10,000 and $\geq$ 100,000 were closer to the overall meta-analysis data, indicating that the results derived from large-sample studies may better represent the real-world situation. Furthermore, in the subgroup regression analysis of 90-day readmission rate, there were subgroup differences according to sample size ($P < 0.05$). It is noteworthy that the number of studies with sample sizes ranging from 500 to 999 was too small; therefore, the effect of sample size on COPD readmission rate should be interpreted with caution. In the region of research subgroup analysis, patients
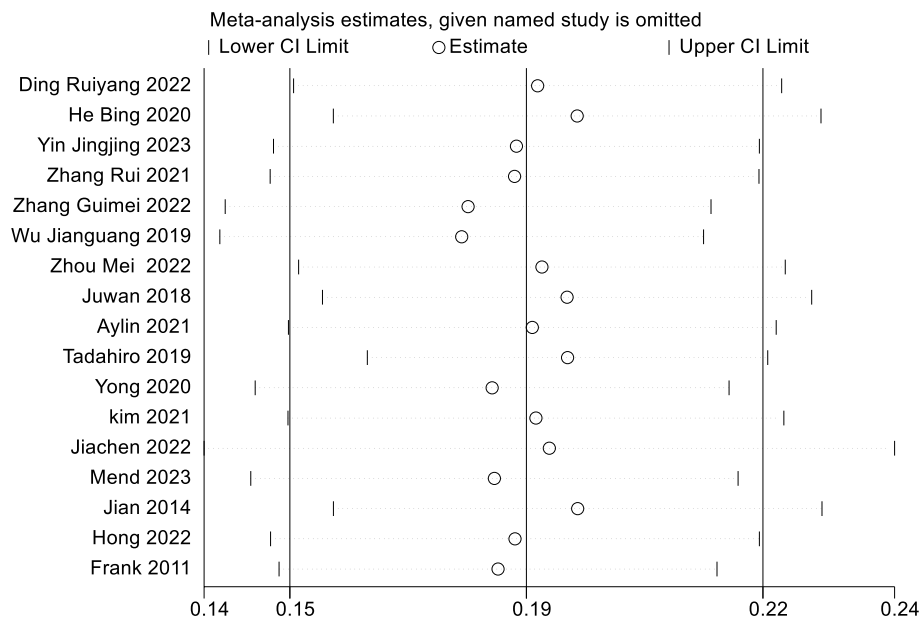
Fig. 5 Sensitivity analysis of included studies on 30-day readmission rate for COPD in Asia
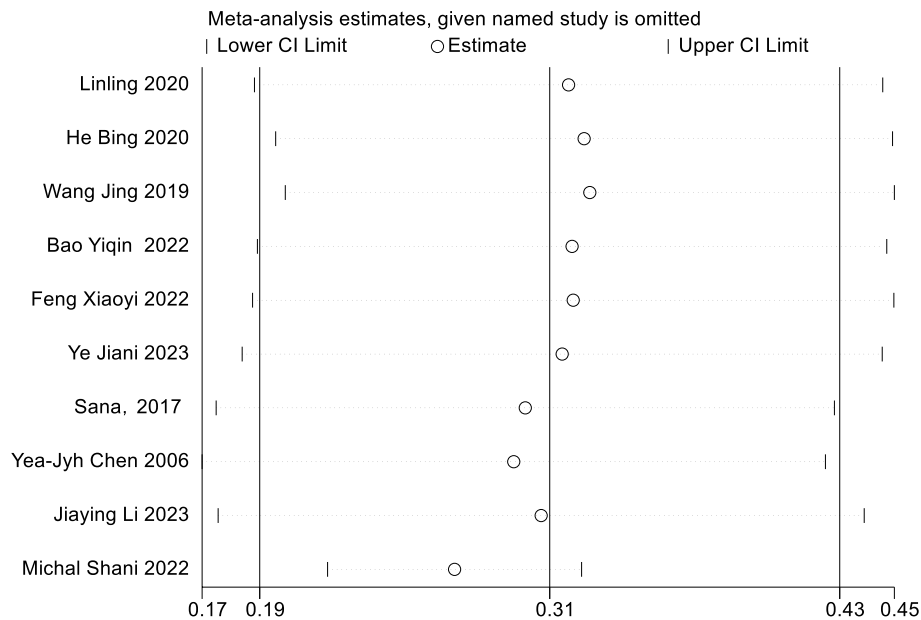

Fig. 6 Sensitivity analysis of included studies on 90 day readmission rate for COPD in Asia

in China and South Korea had higher readmission rates. For the 365-day readmission rate, patients from northern China had a higher readmission rate than those from southern China, which may be attributed to the poor air quality and low temperature in northern China, which are more likely to cause acute attacks and hospitalization. In the subgroup regression of 90-day readmission, subgroup differences were detected by region of research ($P < 0.05$). Nonetheless, there were very few studies from countries other than China and South Korea; therefore, this finding needs

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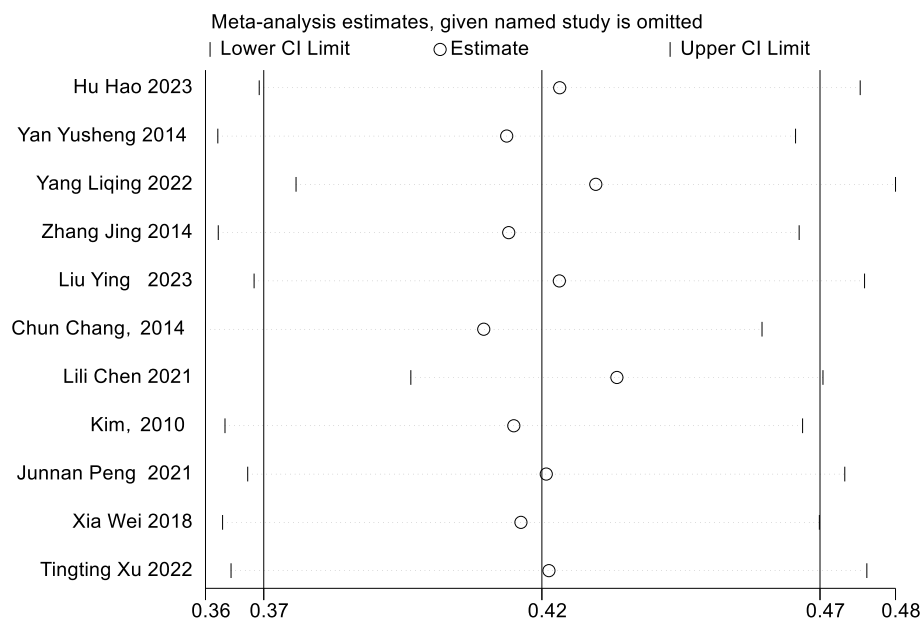
Fig. 7 Sensitivity analysis of included studies on 365 day readmission rate for COPD in Asia

to be confirmed by further large-scale, multicenter, and prospective studies.

Limitations

This study had some limitations: (1) The studies included were retrospective studies, so we could not control for the impact of biases in research design, selection, and measurement. (2) The heterogeneity of the included studies was high. We performed subgroup analyses of study characteristics and detected heterogeneity in terms of age, sample size, and region of research. However, our subgroup analyses only covered available factors and not disease severity, GOLD classification, or comorbidities. This may have had an impact on the meta-analysis results, and the studies included in this meta-analysis had high heterogeneity. Through a subgroup analysis of the characteristics of the included studies, we found that age, sample size, and study area were the main factors leading to heterogeneity. These findings provide important suggestions for future research on readmission in patients with COPD risk factors. In particular, we recommend the following: 1) Improving study accuracy and representativeness. Future studies should focus on reducing heterogeneity. More precise and targeted results could be obtained by a more detailed stratified analysis of factors, such as age, sample size, and study region. This would lead to better understanding of how the risk

factors for acute readmission in patients with COPD differ across populations. 2) Optimizing age groups. Given that the age span is large, future research on patients should be divided into different age groups. This approach could reveal the influence of age on the risk of readmission in patients with COPD, thereby enabling the development of targeted prevention and treatment strategies for patients of different ages. 3) Paying attention to regional differences. Research in different regions could explore the geography, the environment, and medical conditions, such as the influence of risk factors in patients with COPD readmission. This could help to develop more suitable prevention and management strategies for a particular region. 4) Exploring new risk factors in addition to known risk factors. Future research should explore potential new risk factors, such as environmental pollution, lifestyle changes, and emerging complications, to enable comprehensive understanding of the factors that influence readmission among patients with COPD. Standardized assessment tools developed via large sample studies could enable comprehensive and accurate understanding of the risk factors for readmission in patients with COPD. This would enable the development of scientifically informed prevention and management strategies, eventually improving the prognosis and quality of life of patients, and reducing the burden on the health care system.

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**Table 4** Subgroup analysis of COPD in Asia readmission rate within 30 day and 90 day and 365 day

Subgroup	Number of studies	Readmission Rate (%)	95% CI	Heterogeneity Test Results I² (%)	p	Meta-Regression (p)	Effects Model
30-daySubgroup Analyses							
region of research						0.138	
China	12	0.20	0.16-0.24	99	0.000		random effects mode
Korea	3	0.17	0.08-0.27	99	0.000		random effects mode
Turkey	1	0.17	0.13-0.22	/	/		/
Japan	1	0.08	0.07-0.08	/	/		/
study type						0.49	
retrospective studies	13	0.18	0.14-0.22	99	0.000		random effects mode
prospective studies	4	0.22	0.11-0.33	95	0.000		random effects mode
sample size						0.445	
0-499	7	0.21	0.13-0.29	94	0.000		random effects mode
500-999	3	0.14	0.04-0.24	98	0.000		random effects mode
1000-10000	3	0.20	0.16-0.24	91	0.000		random effects mode
≥10000	4	0.18	0.11-0.26	99	0.000		random effects mode
age						<0.05	
60-69years	7	0.21	0.13-0.29	98	0.006		random effects mode
70-79years	12	0.14	0.09-0.18	99	0.000		random effects mode
≥80years	2	0.06	0.02-0.11	97	0.008		random effects mode
90-daySubgroup Analyses							
region of research						<0.05	
China	8	0.26	0.21-0.31	88	0.000		random effects mode
Malaysia	1	0.41	0.30-0.51	/	/		/
other	1	0.61	0.58-0.64	/	/		/
study type						0.212	
prospective studies	5	0.23	0.17-0.29	78	0.000		random effects mode
retrospective studies	5	0.38	0.20-0.56	98	0.000		random effects mode
age						0.661	
60-69years	9	0.32	0.19-0.45	98	0.000		random effects mode
70-79years	1	0.31	0.19-0.43	/	/		/
sample size						<0.05	
0-499	9	0.27	0.22-0.32	87	0.000		random effects mode
500-999	1	0.61	0.58-0.64	/	/	/	/
365-daySubgroup Analyses							
region of research						0.082	
southern China	6	0.39	0.32-0.45	88	0.000		random effects mode
northern China	4	0.45	0.41-0.51	52	0.000		random effects mode
Korea	1	0.49	0.37-0.60	/	/		/
study type						0.461	
retrospective studies	4	0.40	0.30-0.50	88	0.000		random effects mode
prospective studies	7	0.43	0.38-0.48	73	0.000		random effects mode
age						<0.05	
60-69years	5	0.45	0.43-0.50	28	0.000		fixed effects model
70-79years	6	0.38	0.33-0.44	83	0.000		random effects mode
sample size						0.909	
0-499	9	0.43	0.39-0.47	66	0.000		fixed effects model
500-999	1	0.29	0.26-0.33	/	/		/
≥1000	1	0.48	0.40-0.57	/	/		/

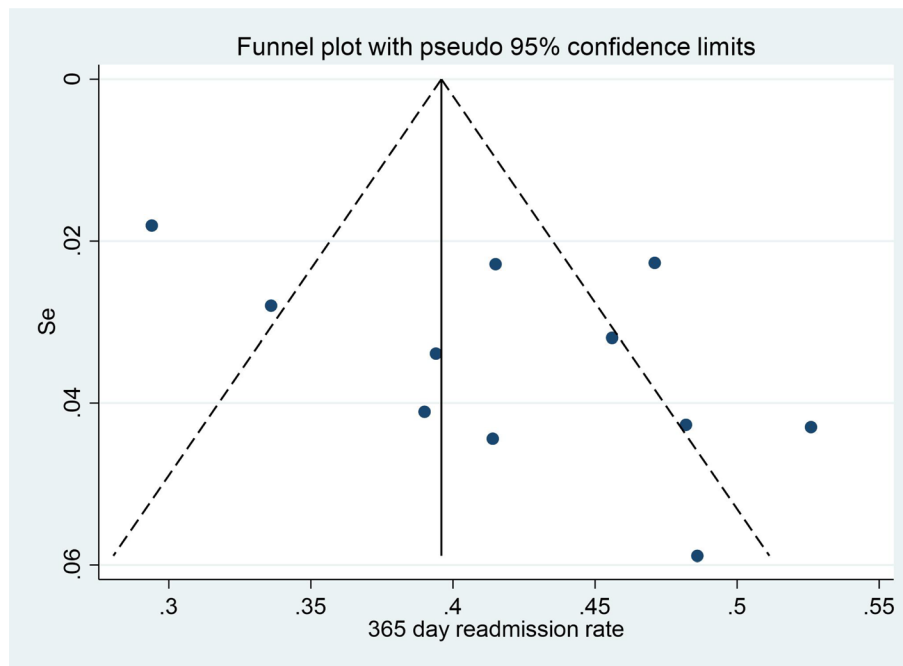*/* means no relevant data
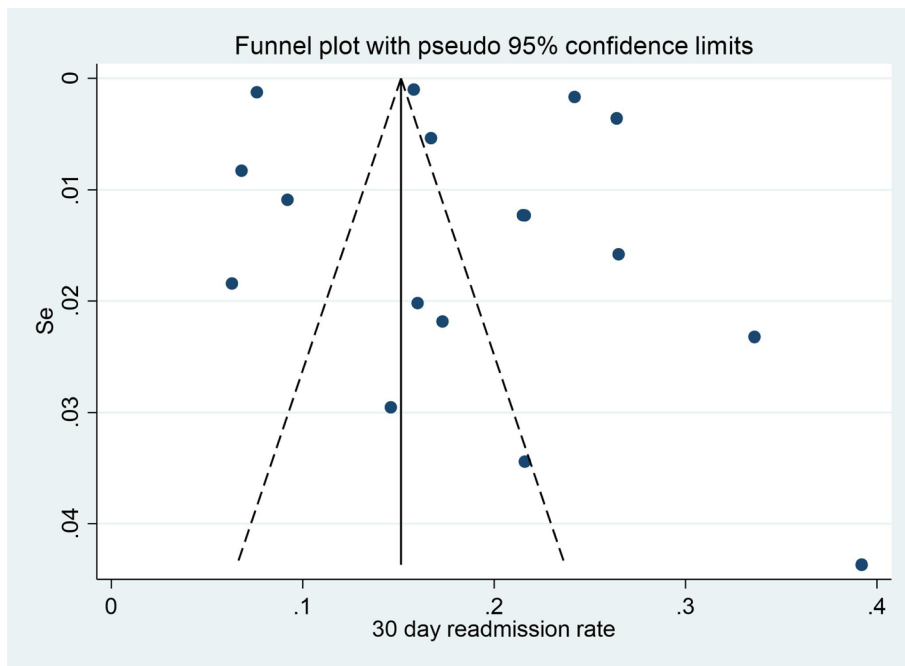
Se:standard error

Fig. 8 Funnel plot of 30 day readmission rate for COPD in Asia
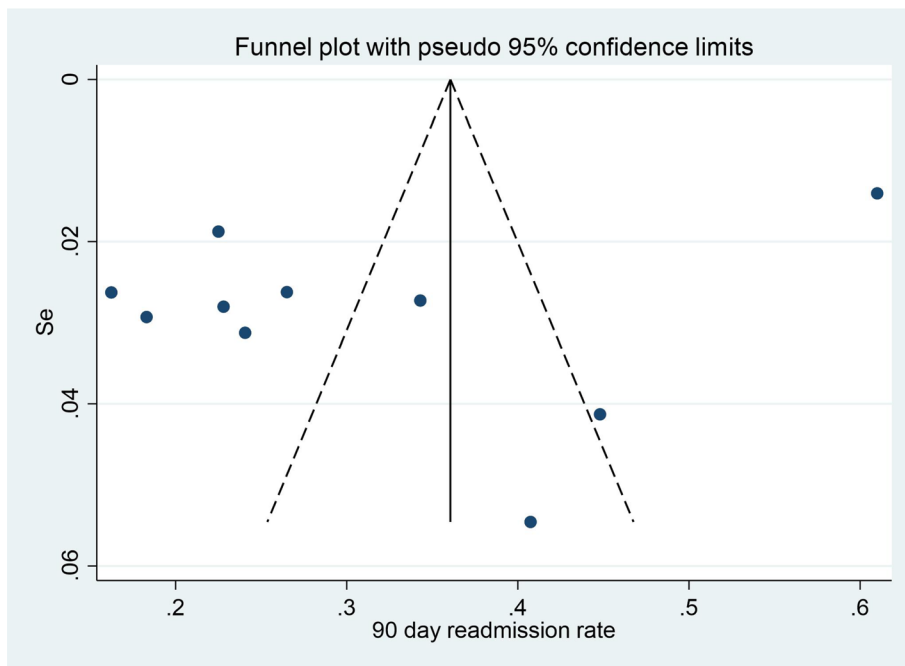
Se:standard error

Fig. 9 Funnel plot of 90 day readmission rate for COPD in Asia

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Se:standard error

Fig. 10 Funnel plot of 365 day readmission rate for COPD in Asia

Conclusion

The existing evidence shows that history of ≥ 2 hospital admissions, ≥ 3 comorbidities, male sex, EOS% ≥ 2%, BMI < 18.5, smoking history, pulmonary heart disease comorbidity, nutritional disorder, NLR > 7, and FEV1 < 50 are risk factors for COPD readmission. The high readmission rates of patients with COPD at 30, 90, and 365 days after discharge were likely related to age, sample size, and the region of research. Based on our findings, it is necessary to pay attention to the prevention, screening, and intervention for relevant population groups and risk factors for COPD to reduce the risk of readmission and healthcare and economic burdens.

Abbreviations

COPD   Chronic obstructive pulmonary disease
EOS   Ratio of eosinophils
CAT   COPD assessment test
NLR   Neutrophil-to-Lymphocyte ratio
BMI   Body mass index
FEV1   Forced expiratory volume in one second

Supplementary Information

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Additional file 1

Availability of data and materials

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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