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Impact of asthma on COVID-19 mortality in the United States: Evidence based on a meta-analysis

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ABSTRACT

Objective: The aim of this study was to investigate the impact of asthma on the risk for mortality among coronavirus disease 2019 (COVID-19) patients in the United States by a quantitative meta-analysis.

Methods: A random-effects model was used to estimate the pooled odds ratio (OR) with corresponding 95% confidence interval (CI). I² statistic, sensitivity analysis, Begg’s test, meta-regression and subgroup analyses were also performed.

Results: The data based on 56 studies with 426,261 COVID-19 patients showed that there was a statistically significant association between pre-existing asthma and the reduced risk for COVID-19 mortality in the United States (OR: 0.82, 95% CI: 0.74–0.91). Subgroup analyses by age, male proportion, sample size, study design and setting demonstrated that pre-existing asthma was associated with a significantly reduced risk for COVID-19 mortality among studies with age ≥ 60 years old (OR: 0.79, 95% CI: 0.72–0.87), male proportion ≥ 55% (OR: 0.79, 95% CI: 0.72–0.87), male proportion < 55% (OR: 0.81, 95% CI: 0.69–0.95), sample sizes ≥ 700 cases (OR: 0.80, 95% CI: 0.71–0.91), retrospective study/case series (OR: 0.82, 95% CI: 0.75–0.89), prospective study (OR: 0.83, 95% CI: 0.70–0.98) and hospitalized patients (OR: 0.82, 95% CI: 0.74–0.91). Meta-regression did reveal none of factors mentioned above were possible reasons of heterogeneity. Sensitivity analysis indicated the robustness of our findings. No publication bias was detected in Begg’s test (P = 0.4538).

Conclusion: Our findings demonstrated pre-existing asthma was significantly associated with a reduced risk for COVID-19 mortality in the United States.

1. Introduction

It has been reported that the prevalence of comorbid asthma among coronavirus disease 2019 (COVID-19) patients varied greatly across countries or regions worldwide [1–3]. Previous meta-analyses have investigated the association between pre-existing asthma and COVID-19 mortality in the whole regions [1–3], but the conclusions were inconsistent, which might suffer limitations from substantial variation of asthma prevalence among different countries. Moreover, a previous meta-analysis by Sunjaya et al reported that COVID-19 patients with asthma had a significantly increased risk for mortality in Asia, but not in Europe, North America and South America [4]. Taken together, those urged us to investigate the association between pre-existing asthma and COVID-19 mortality in a specific country or region. To date, a number of individual studies have explored the association between pre-existing asthma and COVID-19 mortality in the United States with conflicting results [5–9], but no quantitative meta-analysis on this topic was conducted to address this issue. Therefore, we performed a quantitative meta-analysis to investigate the impact of asthma on the risk for COVID-19 mortality in the United States.

2. Methods

2.1. Search strategy and selection criteria

This meta-analysis strictly adhering to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was carried out [10]. We performed an extensive search of the literature in the online databases of PubMed, Wiley Library, Springer Link, Elsevier ScienceDirect, Web of Science, EMBASE, Scopus and Cochrane...
Library to identify all potential articles which were published from inception to October 30, 2021, using the following keywords: “COVID-19”, “coronavirus disease 2019”, “2019-nCoV”, “2019 novel coronavirus”, “SARS-CoV-2”, “severe acute respiratory syndrome coronavirus 2”, “asthma”, “asthmatic”, “mortality”, “fatality”, “death”, “non-survivor”, “deceased”, “US”, “USA”, “America”, “the United States” and “the United States of America”. The references of the included studies and relevant reviews were also searched to identify additional articles. The primary outcome of interest was mortality. The participants of exposure group were COVID-19 patients with asthma and those of control group were COVID-19 patients without asthma.

All studies were included in this meta-analysis when they fulfilled the following inclusion criteria: (1) studies reporting adult confirmed COVID-19 patients in the United States; (2) peer-reviewed articles which were written in English language; (3) studies with the sample sizes being more than fifteen cases; (4) studies with available data on the incidence of survivors and non-survivors among COVID-19 patients with asthma and without asthma or the effect size with 95% confidence interval (CI) regarding the association between asthma and COVID-19 mortality. We excluded case reports, review papers, repeated articles, preprints, errata and studies conducted in other than the United States accordingly. Literature search, study selection and data extraction were performed by two investigators independently. Any disagreement was resolved through discussion between the investigators. The extracted information is at list: first author (PMID), study design, country, sample size, the mean (standard deviation) or median (interquartile range) age respectively, proportion of males, available data on the incidence of survivors and non-survivors among COVID-19 patients with asthma and without asthma or the effect size with 95% CI, and setting.

2.2. Statistical analysis

The pooled odds ratio (OR) with corresponding 95% CI evaluating the association between asthma and COVID-19 mortality in the United States was calculated by a random-effects meta-analysis model [11,12]. I² statistic was applied to assess the heterogeneity among studies [13]. Sensitivity analysis by deleting one single study from overall pooled analysis each time was carried out to evaluate the robustness of the findings [2]. Begg’s rank correlation test was used to evaluate the potential publication bias [14]. The statistical analyses were performed with the package “meta” on R software (Version 4.1.1) [15]. Two tailed P value being less than 0.05 was considered statistically significant.

3. Results

3.1. Study selection

Yielding 5912 records from electronic databases and 10 records from hand-searching from the relevant studies or reviews in the cited lists. 2643 records were identified initially after removing duplicates. After evaluating and assessing as much as 257 full-text articles, 201 full-text articles were excluded due to data deficiencies.

3.2. Study characteristics

A total of fifty-six eligible articles with 426,261 COVID-19 patients were included in our meta-analysis. The sample sizes among the included studies varied from 60 to 219,001 cases. There were forty-six
Table 1
General information of the eligible studies included in this meta-analysis.

| Author (PMID) | Study design            | Region             | Cases | Male (%) | Age       | Asthma Non-survivor | Asthma Survivor | No Asthma Non-survivor | No Asthma Survivor | Setting       |
|---------------|-------------------------|--------------------|-------|----------|-----------|---------------------|-----------------|------------------------|---------------------|---------------|
| Banoei MM     | Retrospective study     | Florida            | 250   | 56       | 62.75 ± 17.13 | 2                  | 28              | 29                     | 191                 | Hospitalized  |
| Chou EH       | Retrospective study     | Texas              | 1788  | 50.2     | 54.6 (41.9–68.2) | 9                | 116             | 188                    | 1475                | All patients  |
| Kim D (PMID: 32950749) | Retrospective study        | The USA           | 817   | 54.47    | 57.13 ± 14.57   | 10               | 78              | 111                    | 618                 | Hospitalized  |
| Garibaldi BT (PMID: 32960455) | Retrospective study | Maryland, Washington | 832   | 53       | 63 (49–75)     | 8                | 71              | 123                    | 630                 | Hospitalized  |
| Kim TS (PMID: 33128484) | Prospective study | New York           | 10,861| 59.6     | NR         | Effect (95% CI): 0.81 (0.67–0.98) |                |                  |                       |               |
| Rustgi V (PMID: 33409033) | Retrospective study | New Brunswick     | 403   | 56.17    | 62.06 ± 18.62  | 4                | 21              | 86                     | 292                 | Hospitalized  |
| Suzuki A (PMID: 34442352) | Cohort study         | Durham             | 22,777| NR       | NR         | 59                | 1254            | 1461                   | 20,003              | All patients  |
| Pecina JL (PMID: 34452582) | Retrospective study | Minnesota          | 92    | 56.5     | 61 (50–74)    | Effect (95% CI): 10.0 (1.8–56.0) |                |                  |                       |               |
| Huang BZ (PMID: 34398424) | Retrospective study | California        | 61,338| 46.08    | 43.97 ± 16.24  | 96               | 5430            | 901                    | 54,911              | All patients  |
| Welder D (PMID: 34132393) | Cohort study         | Texas              | 678   | 52.4     | 61.5 ± 16.7    | 6                | 92              | 50                     | 530                 | All patients  |
| Hou W (PMID: 33746560) | Retrospective study | New York           | 635   | 59.8     | 60 ± 11       | 3                | 38              | 79                     | 515                 | Hospitalized  |
| Forrest IS (PMID: 34084823) | Retrospective study | New York           | 688   | 63.52    | 67.22 ± 14.44  | 13               | 17              | 286                    | 372                 | Hospitalized  |
| Gupta YS (PMID: 33601125) | Retrospective study | New York           | 180   | 53       | 68 (59–80)    | 1                | 6               | 58                     | 115                 | All patients  |
| Jacobs JP (PMID: 34242641) | Prospective study | The USA            | 200   | 69       | 49.8 ± 12.1   | 19               | 14              | 91                     | 76                  | All patients  |
| Chihba KD (PMID: 32554082) | Retrospective study | Chicago            | 1526  | 47       | 53.3         | 8                | 212             | 64                     | 1242                | All patients  |
| Eggert LE (PMID: 34082210) | Retrospective study | California        | 605   | 47.8     | 50.68 ± 26.18  | 6                | 94              | 30                     | 475                 | Hospitalized  |
| Ho KS (PMID: 33647451) | Retrospective study | New York           | 4902  | 55.9     | 64.99 ± 16.92  | 54               | 179             | 1354                   | 3315                | Hospitalized  |
| Lieberman- Cribbin W (PMID: 32522556) | Retrospective study | New York           | 6245  | NR       | 57           | 45               | 227             | 1083                   | 4890                | Hospitalized  |
| Lovinsky-Desir S (PMID: 32771560) | Retrospective study | New York           | 1298  | 41.3     | 52           | 9                | 154             | 101                    | 1034                | Hospitalized  |
| Mather JF (PMID: 34143730) | Retrospective study | Hartford           | 1045  | 33.7     | 56.0 ± 17.58  | 7                | 81              | 157                    | 800                 | Hospitalized  |
| Robinson LB (PMID: 336540461) | Retrospective study | Boston            | 3248  | 72       | 51 ± 17      | 7                | 555             | 69                     | 2617                | All patients  |
| Rosenhal JA (PMID: 33059035) | Retrospective study | Washington         | 727   | NR       | 49.46 ± 17.93 | 10               | 95              | 51                     | 571                 | All patients  |
| Salacup G (PMID: 32613986) | Retrospective study | Pennsylvania       | 242   | 51       | 66 ± 14.75   | 0                | 18              | 52                     | 172                 | Hospitalized  |
| Shah P (PMID: 32600956) | Retrospective study | Georgia            | 522   | 41.8     | 63 (50–72)    | 11               | 57              | 81                     | 373                 | Hospitalized  |
| Miller J (PMID: 32945086) | Retrospective study | Michigan           | 2316  | 51.8     | 64.5 ± 16.3   | 31               | 186             | 402                    | 1697                | Hospitalized  |
| Ioannou GN (PMID: 33565952) | Retrospective study | Washington         | 10,131| 91       | 63.6 ± 16.2   | 58               | 687             | 1032                   | 8354                | All patients  |
| Bahl A (PMID: 32970246) | Prospective study      | Michigan           | 1461  | 52.7     | 62.0 (50.0–74.0) | 30               | 124             | 297                    | 1010                | Hospitalized  |
| Jackson BR (PMID: 32971532) | Retrospective study | Georgia            | 297   | 49.8     | 60 (45–69)   | 3                | 29              | 48                     | 217                 | Hospitalized  |
| Kim J (PMID: 33092732) | Retrospective study | New York           | 510   | 66       | 64 ± 14      | 43               | 341             | 1071                   | 7315                | All patients  |
| Rechtman E (PMID: 33298891) | Retrospective study | New York           | 8770  | 54.3     | 60 (44–72)   | 43               | 341             | 1071                   | 7315                | All patients  |
| Lundon DJ (PMID: 33342596) | Cross-sectional study | New York           | 8928  | 46.2     | 58.0 ± 18.8   | 45               | 358             | 1134                   | 7391                | All patients  |

(continued on next page)
reduced risk for COVID-19 mortality in the United States (OR: 0.82, 95% 
calculating the OR: 0.82, 95% CI: 0.74–0.91) (Fig. 2). Once the participants were only limited to hospital patients, we still observed that pre-existing asthma was associated with a significantly reduced risk for COVID-19 mortality (OR: 0.81, 95% CI: 0.74–0.88, Table 2). Subgroup analyses by age, male proportion, sample size and study design demonstrated that this significant association between asthma and the reduced risk for COVID-19 mortality did exist among studies with separated subgroup: age ≥ 60 years old (n = 34 studies, OR: 0.79, 95% CI: 0.72–0.87, Figure S1), male proportion ≥ 55% (n = 27 studies, OR: 0.79, 95% CI: 0.72–0.87, Figure S2), male proportion < 55% (n = 25 studies, OR: 0.81, 95% CI: 0.69–0.95, Figure S2), sample sizes ≥ 700 cases (n = 28 studies, OR:

3.3. Asthma and mortality of COVID-19

Totally, this present meta-analysis showed that there was a statistically significant association between pre-existing asthma and the reduced risk for COVID-19 mortality in the United States (OR: 0.82, 95% CI: 0.74–0.91) (Fig. 2). Once the participants were only limited to hospital patients, we still observed that pre-existing asthma was associated with a significantly reduced risk for COVID-19 mortality (OR: 0.81, 95% CI: 0.74–0.88, Table 2). Subgroup analyses by age, male proportion, sample size and study design demonstrated that this significant association between asthma and the reduced risk for COVID-19 mortality did exist among studies with separated subgroup: age ≥ 60 years old (n = 34 studies, OR: 0.79, 95% CI: 0.72–0.87, Figure S1), male proportion ≥ 55% (n = 27 studies, OR: 0.79, 95% CI: 0.72–0.87, Figure S2), male proportion < 55% (n = 25 studies, OR: 0.81, 95% CI: 0.69–0.95, Figure S2), sample sizes ≥ 700 cases (n = 28 studies, OR:

Table 1

| Author (PMID) | Study design | Region | Cases | Male (%) | Age | Asthma | Non-survivor | Survivor | No Asthma | Non-survivor | Survivor | Setting |
|---------------|--------------|--------|-------|----------|-----|--------|-------------|----------|-----------|-------------|----------|---------|
| Hobbs ALV (PMID: 33427149) | Retrospective study | Arkansas, Louisiana, Mississippi, North Carolina, and Tennessee | 476 | 55.3 | 62 (49–71) | 5 | 43 | 71 | 357 | Hospitalized |
| Gupta R (PMID: 33461499) | Retrospective study | New York | 475 | NR | NR | Effect (95% CI): 2.77 (1.18–7.04) | Hospitalized |
| Marmarchi F (PMID: 33469873) | Retrospective study | Georgia | 288 | 55 | 63 ± 16 | Effect (95% CI): 0.517 (0.189–1.409) | Hospitalized |
| Mohamed NE (PMID: 33481113) | Case series | New York | 7624 | 54.6 | 46.78 | 33 | 302 | 823 | 6466 | Hospitalized |
| Muhammad R (PMID: 33538998) | Retrospective study | Washington | 200 | 60.5 | 58.9 ± 15.1 | 3 | 17 | 42 | 138 | Hospitalized |
| Lohia P (PMID: 33544658) | Retrospective study | Michigan | 1871 | 51.6 | 64.11 ± 16 | Effect (95% CI): 0.57 (0.38–0.87) | Hospitalized |
| Cedano J (PMID: 33552409) | Retrospective study | New Jersey | 132 | 59 | 63 (53–71) | 6 | 1 | 86 | 39 | Hospitalized |
| Mulhem E (PMID: 33578311) | Retrospective study | New York | 3219 | 49 | 65.2 | 67 | 362 | 449 | 2341 | Hospitalized |
| Kelly JD (PMID: 34106264) | Cohort study | New York | 27,640 | 88.6 | 57.2 ± 16.6 | Effect (95% CI): 0.78 (0.59–1.04) | Hospitalized |
| Ende VJ (PMID: 34397301) | Retrospective study | New York | 294 | 68.7 | 62.61 ± 14.41 | 13 | 17 | 127 | 137 | Hospitalized |
| Zerbo O (PMID: 34432371) | Retrospective study | California | 219,001 | 47.3 | 37.21 | 287 | 31,057 | 1238 | 186419 | Hospitalized |
| Roozi S (PMID: 33845659) | Retrospective study | Pennsylvania | 1204 | 59.3 | 66 | 39 | 83 | 431 | 651 | Hospitalized |
| Al Abbasi B (PMID: 33224366) | Retrospective study | Florida | 257 | 52.53 | 63 ± 17 | 3 | 18 | 53 | 183 | Hospitalized |
| Altonen BL (PMID: 33315929) | Retrospective study | New York | 395 | 66.8 | 31.03 | 8 | 55 | 47 | 285 | Hospitalized |
| Gayam V (PMID: 32672844) | Retrospective study | New York | 408 | 56.62 | 53 | 67 (56–76) | 16 | 38 | 116 | 238 | Hospitalized |
| Morrison AR (PMID: 32646770) | Retrospective study | Michigan | 81 | 69.1 | 64 (58–71) | 5 | 6 | 30 | 40 | Hospitalized |
| Gavin W (PMID: 32652522) | Retrospective study | Indiana | 140 | 51.4 | 60 (48–72) | 1 | 14 | 21 | 104 | Hospitalized |
| Krishna S (PMID: 32701717) | Retrospective study | Michigan | 152 | 62.5 | 66 ± 13 | 16 | 9 | 76 | 51 | Hospitalized |
| Li X (PMID: 33194555) | Retrospective study | New York | 1022 | 56.46 | 62.13 ± 17.45 | 6 | 51 | 136 | 829 | Hospitalized |
| Berry DA (PMID: 33200317) | Retrospective study | Texas | 3123 | 60.36 | 63 (51–74) | 58 | 218 | 637 | 2135 | Hospitalized |
| Vu CA (PMID: 33353546) | Retrospective study | Florida | 60 | 66.7 | 54 (26–87) | 0 | 4 | 9 | 47 | Hospitalized |
| Snider JM (PMID: 34428181) | Retrospective study | New York | 90 | 53.3 | 62.3 | 2 | 5 | 28 | 55 | Hospitalized |
| Mikami T (PMID: 32607928) | Retrospective study | Massachusetts | 835 | 48 | 64 (50–76) | 15 | 66 | 134 | 620 | Hospitalized |
| Akama-Garren EH (PMID: 33408403) | Retrospective study | New York | 142 | 78.17 | 59.27 ± 18.89 | 1 | 1 | 33 | 107 | Hospitalized |

Note: The age (years) was presented as mean ± standard deviation or median (interquartile range, IQR); CI, confidence interval; The USA, the United States; NR, not clearly reported.
Fig. 2. Forest plot presents the relationship between COVID-19 mortality and asthma in the United States: pooled odds ratio (OR) with its 95% confidence interval (CI).
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38x63 terms of suppressing viral replication and relieving inflammation [68]; and biological agents, may resist the severe prognoses of COVID-19 in asthma in convention, allergen immunotherapy, inhaled corticosteroids (3) type 2 immune response modulating the expression of ACE2 and TMPRSS2 further supports an important role in inflammatory process in COVID-19 pathogenesis [69].

The prevalence of comorbid asthma among coronavirus disease 2019 patients varied greatly across countries or regions worldwide. Previous meta-analyses have reported the inconsistent association between asthma and COVID-19 mortality in the whole regions [1–3], which might be difficult in assessing the association on substantial variation of asthma prevalence among different countries. The strength of this study was that the included studies (56 eligible articles) with 426,261 cases were only conducted in the USA, which thought about the influences of this varied prevalence for asthma in regions among COVID-19 patients in the USA in terms of the relation between asthma and COVID-19 mortality. The meta-analysis only including studies conducted in the USA supported that pre-existing asthma was significantly associated with a reduced risk for COVID-19 mortality, which wards off the diversity of epidemiological characteristics and prevention and control measures in region, for the most part.

Undeniably, we indeed acknowledged that there were several limitations in this present meta-analysis. First, most of the included studies were retrospective, only four prospective studies were included, thus further meta-analyses on this topic based on prospective studies are warranted to confirm our results when more eligible data are available. Second, the pooled effect size was estimated on the crude effect sizes, which could not address the effects of certain confounders on the association between asthma and COVID-19 mortality. Therefore, further studies based on risk factors-adjusted estimates are warranted to verify our current findings. Third, this study could not address the effects of medications on the association between asthma and COVID-19 mortality, since most of the included studies did not provide the data. Forth, we noticed that the data of several studies were collected from multiple hospitals or centers, thus overlapping data might occur. In order to include more data as more as possible, we did not exclude the studies containing multiple hospitals or centers.

In conclusion, our findings demonstrated that pre-existing asthma was significantly associated with a reduced risk for COVID-19 mortality in the United States, further well-designed studies based on risk factors-adjusted estimates are warranted to confirm our findings. This study suggested that routine interventions and treatment for asthma patients with severe acute respiratory syndrome coronavirus 2 infection should be continued in the United States.
| Study                        | Odds Ratio | OR   | 95%–CI       |
|-----------------------------|------------|------|--------------|
| Omitting Akama–Garren EH    | 0.82       | [0.74; 0.91] |
| Omitting Al Abbasi B        | 0.82       | [0.74; 0.91] |
| Omitting Altonen BL         | 0.82       | [0.74; 0.91] |
| Omitting Bahl A             | 0.82       | [0.74; 0.91] |
| Omitting Banoei MM          | 0.82       | [0.74; 0.91] |
| Omitting Berry DA           | 0.82       | [0.74; 0.91] |
| Omitting Cedano J           | 0.82       | [0.74; 0.91] |
| Omitting Chhiba KD          | 0.82       | [0.74; 0.91] |
| Omitting Chou EH            | 0.82       | [0.74; 0.91] |
| Omitting Eggert LE          | 0.82       | [0.74; 0.91] |
| Omitting Ende VJ            | 0.82       | [0.74; 0.91] |
| Omitting Forrest IS         | 0.82       | [0.74; 0.91] |
| Omitting Garibaldi BT       | 0.82       | [0.74; 0.91] |
| Omitting Gavin W            | 0.82       | [0.74; 0.91] |
| Omitting Gayarn V           | 0.82       | [0.74; 0.91] |
| Omitting Gupta R            | 0.82       | [0.74; 0.90] |
| Omitting Gupta YS           | 0.82       | [0.74; 0.91] |
| Omitting Ho KS              | 0.82       | [0.74; 0.91] |
| Omitting Hobbs ALV          | 0.82       | [0.74; 0.91] |
| Omitting Hou W              | 0.82       | [0.74; 0.91] |
| Omitting Huang BZ           | 0.82       | [0.74; 0.91] |
| Omitting Ioannou GN         | 0.82       | [0.74; 0.91] |
| Omitting Jackson BR         | 0.82       | [0.74; 0.91] |
| Omitting Jacobs JP          | 0.82       | [0.74; 0.91] |
| Omitting Kelly JD           | 0.82       | [0.74; 0.91] |
| Omitting Kim D              | 0.82       | [0.74; 0.91] |
| Omitting Kim J              | 0.82       | [0.74; 0.91] |
| Omitting Kim TS             | 0.82       | [0.74; 0.91] |
| Omitting Krishnan S         | 0.82       | [0.74; 0.91] |
| Omitting Li X               | 0.82       | [0.74; 0.91] |
| Omitting Lieberman–Cribbin W| 0.82       | [0.74; 0.91] |
| Omitting Lohia P            | 0.82       | [0.74; 0.91] |
| Omitting Lovinsky–Desir S   | 0.82       | [0.74; 0.91] |
| Omitting Lundon DJ          | 0.82       | [0.74; 0.91] |
| Omitting Marmarchi F        | 0.82       | [0.74; 0.91] |
| Omitting Mather JF          | 0.82       | [0.74; 0.91] |
| Omitting Mikami T           | 0.82       | [0.74; 0.91] |
| Omitting Miller J           | 0.82       | [0.74; 0.91] |
| Omitting Mohamed NE         | 0.82       | [0.74; 0.91] |
| Omitting Morrison AR        | 0.82       | [0.74; 0.91] |
| Omitting Muhammad R         | 0.82       | [0.74; 0.91] |
| Omitting Mulhem E           | 0.82       | [0.74; 0.91] |
| Omitting Pecina JL          | 0.82       | [0.74; 0.91] |
| Omitting Rechtman E         | 0.82       | [0.74; 0.91] |
| Omitting Robinson LB        | 0.82       | [0.74; 0.91] |
| Omitting Roomi S            | 0.82       | [0.74; 0.91] |
| Omitting Rosenthal JA       | 0.82       | [0.74; 0.91] |
| Omitting Rustgi V           | 0.82       | [0.74; 0.91] |
| Omitting Salacup G          | 0.82       | [0.74; 0.91] |
| Omitting Shah P             | 0.82       | [0.74; 0.91] |
| Omitting Snider JM          | 0.82       | [0.74; 0.91] |
| Omitting Sulaiman I         | 0.82       | [0.74; 0.91] |
| Omitting Suzuki A           | 0.82       | [0.74; 0.91] |
| Omitting Vu CA              | 0.82       | [0.74; 0.91] |
| Omitting Welder D           | 0.82       | [0.74; 0.91] |
| Omitting Zerbo O            | 0.82       | [0.74; 0.91] |

Random effects model 0.82 [0.74; 0.91]

Fig. 3. Sensitivity analysis for pooled OR and 95% CI by deleting one single study from overall pooled analysis each time.
Fig. 4. Publication bias based on funnel plot.

Author contribution

Haiyan Yang and Yadong Wang conceptualized the study. Xueya Han, Jie Xu, Hongjie Hou and Haiyan Yang performed literature search and data extraction. Xueya Han, Jie Xu and Hongjie Hou analyzed the data. Xueya Han and Yadong Wang wrote the manuscript. All the authors approved the final manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability statement

The data that support the findings of this study are included in this article and available from the corresponding author upon reasonable request.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.intimp.2021.108390.

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