

REVIEW

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Efficacy of *Nigella sativa* in COVID-19 patients: a systematic review and meta-analysis

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Abstract

Background The COVID-19 pandemic has necessitated the investigation of potential treatment options to alleviate symptoms, reduce severe infection rates, and reduce mortality rates. Previous research on *Nigella sativa*, a phytomedicine with various therapeutic properties, has shown promise. This study aims to determine the efficacy of *Nigella sativa* as a treatment option for COVID-19 patients.

Methods We carried out a thorough systematic review of relevant literature from multiple databases until May 2024. Eligible studies were randomized controlled trials (RCTs) that investigated the efficacy of *Nigella sativa* as a treatment for COVID-19. We utilized the Cochrane Revised Risk of Bias 2 (ROB 2.0) to assess the quality of each included study. We carried out statistical analysis using RevMan version 5.4.

Results The meta-analysis included a total of six studies with a total of 1595 COVID-19 patients. The use of *Nigella sativa* significantly reduced the severity of infection symptoms (OR=0.08, 95% CI [0.02 to 0.25], $P < 0.0001$) and demonstrated a significant reduction in mortality rates ($P = 0.383$). Also, it significantly reduced CRP levels (MD = -3.287, 95% CI [-4.620 to -1.955], $P < 0.00001$) and the overall likelihood of patients experiencing headache (OR = 0.82, 95% CI [0.76 to 0.89], $P < 0.00001$). Furthermore, in contrast, our study found no statistically significant effect of *Nigella sativa* on common COVID-19 symptoms such as fever, cough, fatigue, and ferritin levels, a key inflammatory marker. Similarly, it had no effect on the occurrence of rhinorrhea or shortness of breath among patients.

Conclusion This meta-analysis provides evidence that *Nigella sativa* is effective as a potential treatment option for COVID-19 patients. The use of this phytomedicine significantly reduces the likelihood of patients experiencing headaches and severe infection symptoms.

Keywords COVID-19, *Nigella sativa*, Phytomedicine, Infection

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Introduction

The COVID-19 pandemic has caused a global health crisis, resulting in a mortality rate of approximately 3.4% of reported cases worldwide [7]. Despite advancements in medical research, there are limited pharmacotherapeutic drugs available to effectively treat COVID-19, leading to ongoing concerns about mortality rates. Additionally, some populations have shown low acceptance of COVID-19 vaccines, highlighting the need for improved treatment strategies.

As a result, herbal medicines such as *Nigella sativa* (black seed) and vitamin D3 are being investigated for their potential as complementary treatments for coronavirus infections [20]. These substances have gained attention due to their anti-inflammatory, antiviral, and immunomodulatory properties [13, 32]. *Nigella sativa* has been traditionally used for various health issues and has shown promising results in reducing viral load and increasing IFN- γ levels and function in patients infected with murine cytomegalovirus [34]. Furthermore, laboratory studies have demonstrated that a formulation of *Nigella sativa* called Alpha-zam selectively inhibits the Hepatitis C virus in cells [27].

A clinical trial conducted on patients with hepatitis C virus showed that taking 450 mg of *Nigella sativa* oil three times a day for three months resulted in a significant reduction of over 50% in virus levels [4]. *Nigella sativa* extract effectively reduced the coronavirus load to undetectable levels within 6 h after infection, while the control group only experienced a 10% reduction after 8 h [39]. In silico models also demonstrated that certain compounds found in *N. sativa* inhibited coronavirus replication (D. A. E. [17]). Another clinical trial found that women following a low-calorie diet and supplemented with 3 g of *Nigella sativa* oil for eight weeks experienced significant decreases in tumor necrosis factor-alpha and C-reactive protein levels compared to the placebo group.

It was also discovered that *Nigella sativa* enhanced natural killer cell activity and improved T-cell immunity [21, 31]. Furthermore, studies have shown that vitamin D3 supplementation can enhance the function of macrophages and dendritic cells, which are crucial for immune response. This improvement in immune function may contribute to the innate and adaptive immune response against pathogens like SARS-CoV-2. Moreover, vitamin D3 has been found to inhibit the main protease (M^{PRO}) of the SARS-CoV-2 virus. Said et al. conducted a study that demonstrated the positive effects of *Nigella sativa* and Vitamin D supplementation on the clinical symptoms of COVID-19 patients [29]. However, Bin Abdulrahman's research [5] found that *Nigella sativa* significantly impacted symptoms and inflammatory markers in COVID-19 patients, leading to inconsistent and diverse results.

Prior review [18] summarized preliminary clinical signals of *Nigella sativa* in COVID-19. Our review complements this work by expanding to synthesize evidence from randomized controlled trials (RCTs) on the efficacy of *Nigella sativa* on clinical outcomes for COVID-19 patients, broadening outcomes to include symptom severity and inflammatory markers (e.g., C-reactive protein), and updating the evidence base through our last search date.

Methods

We performed this review according to the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) guidelines [28]. We conducted this systematic review and meta-analysis and registered it in Prospero (registration number CRD42023449783).

Inclusion and exclusion criteria

We included the studies that meet the following criteria: 1) RCTs only, 2) population: COVID-19 patients, 3) Intervention: *Nigella sativa*, 4) Comparator: placebo, 5) outcomes: mortality, and clinical symptoms of patients. We excluded observational studies, case reports, animal studies, non-English studies, and studies that were not completed at the time of the search.

Search strategy and selection process

We conducted a comprehensive literature search through PubMed, Scopus, Web of Science, and Embase for relevant studies until May 28, 2024. We have updated the search to 17th of October 2025 and found no new studies to add to the systematic review. The keywords used in the search were ("*Nigella sativa*" OR "black seed" OR "black cumin" OR "kalonji") AND (COVID-19 OR SARS-CoV-2 OR coronavirus) (see supplementary Table 1 for the complete search strategies). Two independent researchers screened the titles and abstracts of the obtained records using the Rayan website [26]. After that, two other researchers screened the full text for the eligible studies. We resolved any conflict by discussion with a third researcher.

Data extraction

Two researchers individually extracted information from each eligible trial based on a predesigned form, including study characteristics (author, study year, country, and study type, Number of centers, sample size, follow-up duration and conclusion), Baseline patient characteristics (age, sex, duration of symptoms and comorbidities), and outcomes of interest. Finally, two other researchers cross-checked the extracted data.

Table 1 Summary of characteristics included in studies

Study ID	Study design	Country	Number of centers	Total Participants	Follow up duration(day)	Inclusion criteria	Main outcomes	conclusion
Ashraf 2023 [3]	Multicenter placebo-controlled randomized clinical trial	Pakistan	4	313	30	The viral nucleic acid-positive, adult males and nonpregnant females who presented to seek medical care within 96 h of ailment underwent randomization	The primary outcomes were viral clearance (negative RT-PCR for the SARS-CoV-2 RNA), alleviation of clinical symptoms, lowered CGS score on day 6, and 30-day mortality	The HNS treatment promotes quicker recovery and viral clearance and reduces mortality in COVID-19 patients. Furthermore, it showed no adverse effects on the recipients. As both natural products are relatively inexpensive and widely available, HNS may represent an affordable and over-the-counter treatment for COVID-19 patients
Abdulrahman 2022 [5]	Double-blind placebo-controlled prospective, multiple-armed clinical trial	Saudi Arabia	1	262	10	(1) 18 up to 85 years, (2) Positive COVID-19 PCR diagnostic test for COVID-19, and (3) Not in severe respiratory distress that requires critical care and admission to the ICU	The effect of Nigella sativa on signs and symptoms of mild cases	As a natural product, the effect of Nigella sativa on disease requires weeks to manifest itself. The current RCT did not reveal a significant effect of ten days of treatment with various doses of Nigella sativa on symptoms and inflammatory markers in COVID-19 patients. Therefore, it is not recommended to study the effect of an herb on subsiding self-limited diseases
Al-Haidari 2021 [6]	Randomized, and open-label study	Iraq	1	419	70	patients diagnosed with covid-19 by positive (PCR) test on throat swab samples	describe the association between black seeds group and severity as well as the outcome of infection with covid19	N. sativa has been proven as a safe and potent adjunctive therapeutic agent against COVID-19. It reduces complications and prevents deaths. So, it is likely to lower the burden on health care systems in a significant manner
Ko-shak 2021 [16]	Prospective, two-arm, parallel-group, randomized, controlled	Saudi Arabia	1	183	14	Consecutive adult patients aged 18 and above with mild COVID-19	the percentage of patients who recovered (symptom-free for 3 days) within 14-days	NSO supplementation was associated with faster recovery of symptoms than usual care alone for patients with mild COVID-19 infection. These potential therapeutic benefits require further exploration with placebo-controlled, double-blinded studies

Table 1 (continued)

Study ID	Study design	Country	Number of centers	Total Participants	Follow up duration(day)	Inclusion criteria	Main outcomes	conclusion
Said 2022 [29]	Randomized, controlled, open-label study	EGYPT	1	120	14	age 18–65 years and patients with mild to moderate COVID-19 symptoms according to the classification of Gandhi et al. (2020)	h the viral clearance indicated by a negative polymerase chain reaction (PCR) and the alleviation of symptoms during the study follow-up duration of 14 days	The current work confirms the clinical benefits of Nigella sativa and vitamin D3, and to the best of our knowledge, no study has evaluated the effect of this combination up to date
Karimi 2021 [12]	Multicenter open-labeled, randomized, controlled clinical trial	Iran	5	364	28	the age range of 18 to 75 years in both genders with one or more of the following symptoms: acute respiratory disease (ARI); RR > 30; oxygen saturation < 93%; pulmonary infiltration in chest x-ray; absence of intubation; and lack of any serious concomitant disease of the heart, brain, and lungs, and metabolic disorders	the duration of hospital stays, and secondary outcomes were clinical improvement of symptoms based on a self-assessment questionnaire	The present study demonstrated that this natural decoction and capsules treatment plus routine care significantly decreased the duration of hospital stay, accelerate clinical improvement, and alleviated symptoms such as fever, dry cough, anorexia, muscle pain, and runny nose

RCT Randomized Clinical Trial, *MC* Multicenter, *PC* Placebo-Controlled, *DB* Double-Blind, *OL* Open-Label, *SA* Saudi Arabia, *PK* Pakistan, *IQ* Iraq, *EG* Egypt, *IR* Iran, *Pt* Participants, *FU* Follow-Up, *d* days, *PCR* Polymerase Chain Reaction, *RT-PCR* Reverse Transcriptase PCR, *ICU* Intensive Care Unit, *NS* Nigella sativa, *NSO* Nigella sativa Oil, *HNS* Honey + Nigella sativa, *ARI* Acute Respiratory Infection, *RR* Respiratory Rate, *SpO₂* Oxygen Saturation, *CGS* Clinical Grading Score

Quality assessment

In our evaluation, we utilized the Cochrane Revised Risk of Bias (ROB 2.0) [33] to assess the quality of each study, specifically focusing on randomized controlled trials. This comprehensive approach considers five key domains: randomization bias, bias arising from deviations in intervention implementation, missing outcome data, the appropriateness of outcome measures employed, and potential biases in outcome reporting. When disagreements arose between the two authors' assessments, discussions were promptly held to reach a consensus.

Data synthesis

The collected data will be subjected to analysis utilizing Review-Manager software version 5.4. In order to evaluate the heterogeneity among the studies, Cochran's Q test (where significant heterogeneity is defined as $I^2 = 50\%$) will be utilized [11]. If presenting the included studies' results through a meta-analysis proves unfeasible, we will conduct a systematic review instead of a statistical

synthesis. Binary outcomes were pooled as odds ratios (ORs) with 95% confidence intervals (95% CI), and continuous outcomes as mean differences (MD) and 95% CI. Random-effects models were applied when between-study heterogeneity was evident (Cochran's Q $p < 0.10$ and/or $I^2 > 50\%$); otherwise, fixed-effect models were used. A p-value lower than 0.05 was considered statistically significant. We could not assess publication bias or conduct meta-regression due to the limited number of included studies [8, 23].

Results

Search result

Our search retrieved 521 articles. Only 24 titles were eligible for full-text screening following the title and abstract screening. (Fig. 1) Finally, six studies were included [3, 5]; "Clinical trial of black seeds against COVID-19 in Kirkuk city/Iraq," 2021; [12, 16, 29] with a total of 859 patients for Nigella sativa and 736 patients for the control. All included studies were randomized controlled clinical trials. Two studies were conducted

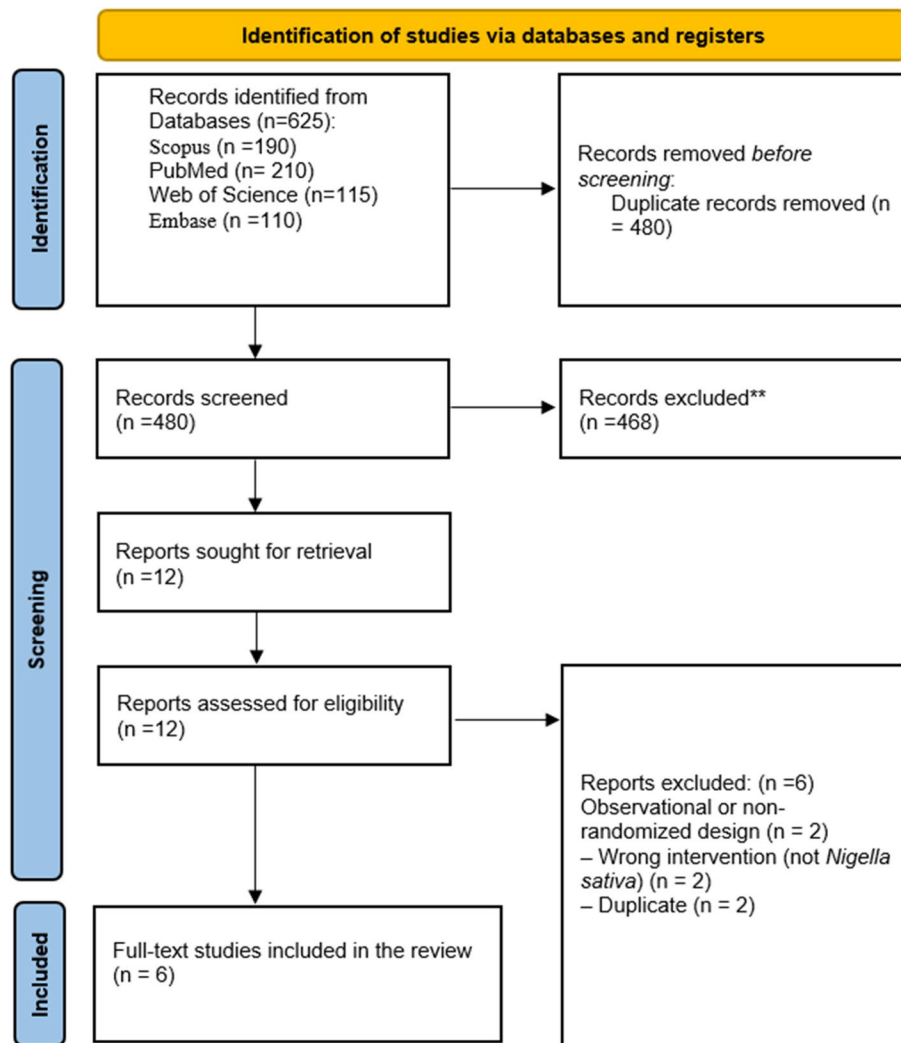


Fig. 1 PRISMA flow diagram of the selection process

in Saudi Arabia, while one study each was conducted in Egypt, Iraq, Pakistan, and Iran. Table 1 summarizes the included studies and their most significant findings.

The mean age of patients varied across studies, with the youngest mean being 35.2 years in the *Nigella sativa* subgroup of Abdulrahman's 2022 study [5] and the oldest mean being 50.79 years in the control group of Karimi's 2021 study [12]. The proportion of male patients also varied, with the highest being 69.6% in the *Nigella sativa* subgroup of Abdulrahman's 2022 study [5]. The prevalence of smoking, dyslipidemia, asthma, and obesity was reported in some studies but not all of them [3, 5, 6]. Table 2 illustrates the detailed baseline characteristics of patients in the included studies.

Quality of included studies

RoB-2 revealed that all included studies showed a low risk of bias. Most of the included studies had some concerns of bias in terms of detection bias. Figure 2 displays

the detailed quality assessment domains of the included studies.

Primary outcomes

Regarding headache outcome, the pooled analysis of four studies favored *Nigella sativa* (OR=0.82, 95% CI [0.76 to 0.89], $P<0.00001$) with insignificant heterogeneity ($I^2=34\%$, $P=0.21$). In terms of CRP, the pooled mean difference (MD) from three studies between *Nigella sativa* and the control favored *Nigella sativa* (MD=-3.287, 95% CI [-4.620 to -1.955], $P<0.00001$) with homogenous results ($I^2=0\%$, $P=0.992$). The pooled Odds Ratio of severity of infection symptoms favored *Nigella sativa* (OR=0.08, 95% CI [0.02 to 0.25], $P<0.0001$) with homogenous results ($I^2=0\%$, $P=0.46$). Mortality was significantly lower in the *Nigella sativa* group (OR=0.216, 95% CI [0.075 to 0.620], $P=0.0006$) with insignificant heterogeneity ($I^2=0\%$, $P=0.383$) (see Fig. 3).

Table 2 Baseline characteristics of included studies

Study ID	Subgroup	Age (Years) Mean (SD)	Gender (Male) n (%)	Hyper- tension n (%)	Diabetes n (%)	BMI mean (SD)	Smok- er n %	Dys- lipid- emia n %	Asth- ma n %	Obe- sity n %	Duration of Hospitaliza- tion/symptoms days mean (SD)
Ashraf 2023 [3]	Nigella sativa	NR	90 (57.32)	48 (30.57)	55 (35.03)	NR	NR	NR	NR	NR	NR
	control	NR	88 (56.41)	51 (32.69)	60 (38.46)	NR	NR	NR	NR	NR	NR
Abdulah- man 2022 [5]	Nigella sativa	35.2 ± 11.4	165(69.6)	NR	NR	NR	NR	NR	NR	NR	NR
	control		18 (72)	NR	NR	NR	NR	NR	NR	NR	NR
Al-Haidari 2021 [6]	Nigella sativa	NR	80 (19.1)	15 (3.5)	5 (1.2)	NR	NR	NR	NR	NR	NR
	control	NR	132 (31.5)	22 (5.3)	9 (2.1)	NR	NR	NR	NR	NR	NR
Koshak 2021 [16]	Nigella sativa	35 ± 10	48 (53)	13 (14)	11 (12)	27 ± 5.9	12 (13)	0 (0.0)	3 (3)	20 (22)	3.5 ± 2.1
	control	36 ± 12	49 (53)	3 (3%)	3 (3)	27.2 ± 5.4	9 (10)	1 (1)	4 (4)	25 (27)	4 ± 2.9
Said 2022 [29]	Nigella sativa	37.3 ± 31.9	18 (60)	26 (86.7)	27 (90)	0 (0.0)	NR	NR	NR	NR	NR
	control	37 ± 33.5	21 (70)	30 (100.0)	30 (100)	0 (0.0)	NR	NR	NR	NR	NR
Karimi 2021 [12]	Nigella sativa	48.72 ± 14.863	106 (58.1)	NR	NR	NR	NR	NR	NR	NR	NR
	control	50.79 ± 15.878	91 (57.7)	NR	NR	NR	NR	NR	NR	NR	NR

SD Standard Deviation, NR Not Reported, n (%) number (percentage), BMI Body Mass Index, HTN Hypertension, DM Diabetes Mellitus, DLP Dyslipidemia, Asth Asthma, Obes Obesity, Smk Smoker, Dur Duration, Hosp Hospitalization, Symp Symptoms, yrs years, M Male

Secondary outcomes

In terms of fever, pooled analysis of four studies showed an insignificant difference between the two groups with significant heterogeneity (OR=0.53, 95% CI [0.14 to 1.98], $P=0.34$, $I^2=91\%$, $P<0.00001$). Pooled data from four studies showed an insignificant difference between the two groups regarding cough (OR=1.05, 95% CI [0.66 to 1.66], $P=0.83$, $I^2=53\%$, $P=0.09$) and fatigue (OR=0.36, 95% CI [0.06 to 2.30], $P=0.28$, $I^2=95\%$, $P<0.00001$). Regarding rhinorrhea, the overall OR of four studies between the nigella sativa and the control did not favor either of the two groups (OR 0.83, 95% CI [0.65 to 1.06], $P=0.14$, $I^2=43\%$, $P=0.15$). Also, the pooled analysis of two studies of the ferritin outcome showed that there was no significant difference between the Nigella sativa drug and the control drug, favoring the control drug with insignificant heterogeneity (MD 6.573, 95% CI [-0.66 to 1.66], $P=0.83$, $I^2=0\%$, $P=0.808$) (See Fig. 4).

Discussion

Across randomized evidence, Nigella sativa improved selected clinical outcomes and inflammatory markers without raising safety concerns. In pooled analyses, we observed a statistically significant reduction in all-cause mortality, alongside improvements in symptom severity and C-reactive protein in subsets. Effect heterogeneity was present but did not reverse directionality. While preliminary and based on small trials, these results suggest potential adjunctive benefits that warrant larger, rigorously controlled studies.

The medicinal use of *Nigella sativa* spans common ailments (fever, headache, common cold) [35], respiratory conditions (allergies, asthma) [14], and dermatologic/wound indications [1]. Our systematic review and meta-analysis of six randomized controlled trials adds

to this literature by focusing on randomized evidence and by synthesizing mortality, symptoms, and CRP in a unified framework. Consistent with prior signals from avian influenza (H9N2) [40], hepatitis C [4], and other coronaviruses [39], we found reductions in headache and improvements in selected outcomes, whereas effects on several predominant COVID-19 symptoms (fever, cough, fatigue, rhinorrhea, dyspnea) and ferritin were not statistically significant overall—highlighting outcome-specific variability that merits targeted evaluation.

The specific chemical composition of Nigella sativa appears to play a crucial role in its therapeutic efficacy due to its immune-modulatory and anti-histaminic effects. Active ingredients of N. sativa are primarily found in the fixed or essential oil of seeds, with compounds such as flavonoids and phenolics shown to interact with the SARS-CoV-2 spike protein-human angiotensin-converting enzyme-2 receptor complexes [38]. Additionally, thymoquinone, another component of the seeds, demonstrates potential in reducing oxidative stress, modulating key immune modulators, and binding to the receptor site on the transmembrane serine protease 2- the enzyme responsible for facilitating the virus's connection to the cell. This interaction reduces the likelihood of a cytokine storm [25]—a key factor in the pathogenesis of COVID-19 infection, and inhibits the virus's progression [19, 37]. The multifaceted therapeutic properties of Nigella sativa encompass antioxidant, anti-inflammatory, antiviral, and antineoplastic attributes [2, 22]. Our findings reveal a notable reduction in mortality rates by over 78.4%, aligning with a prior systematic review, which posited that oral administration of N. sativa when combined with standard care markedly lowered the risk of mortality during hospitalization [18].

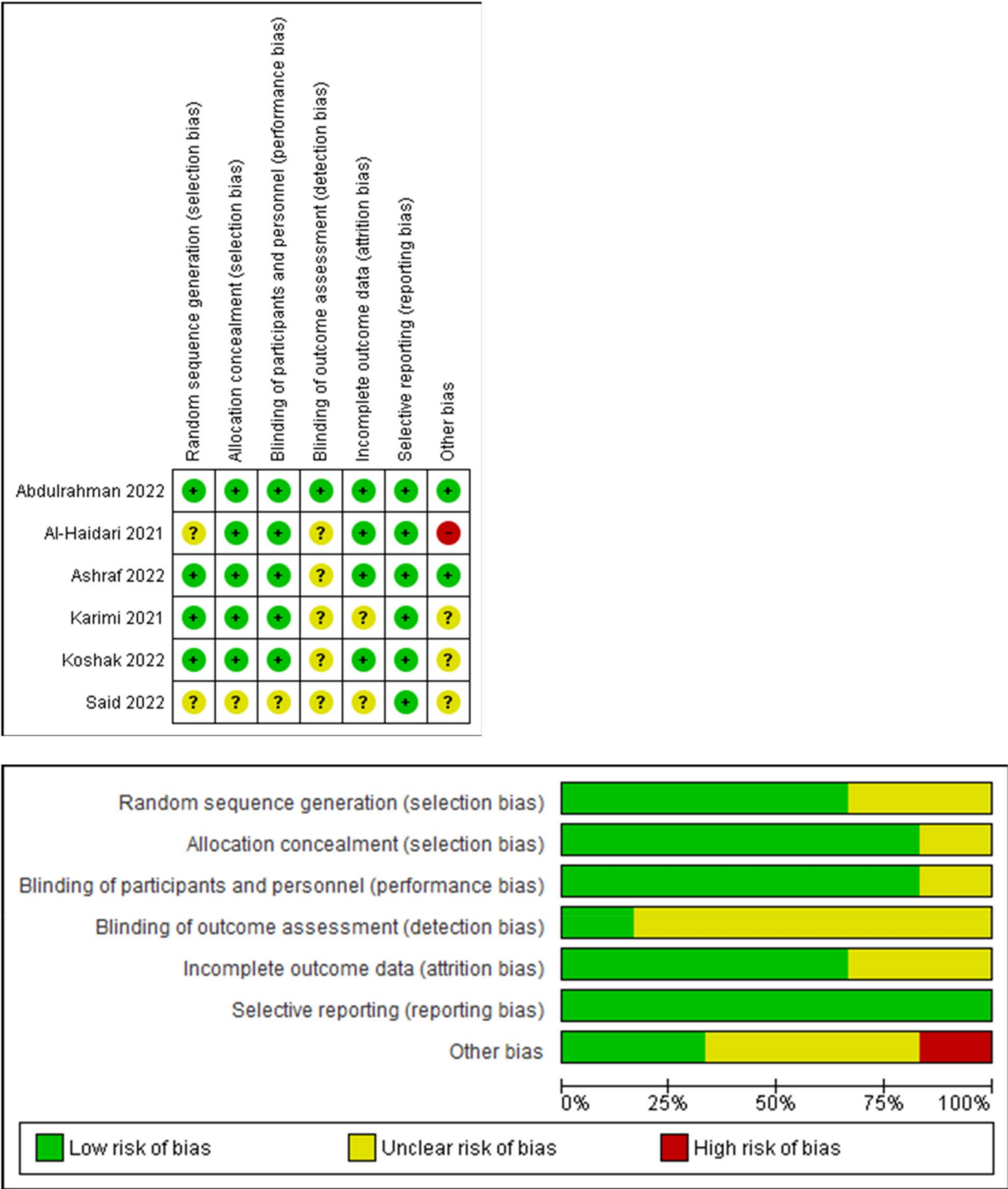
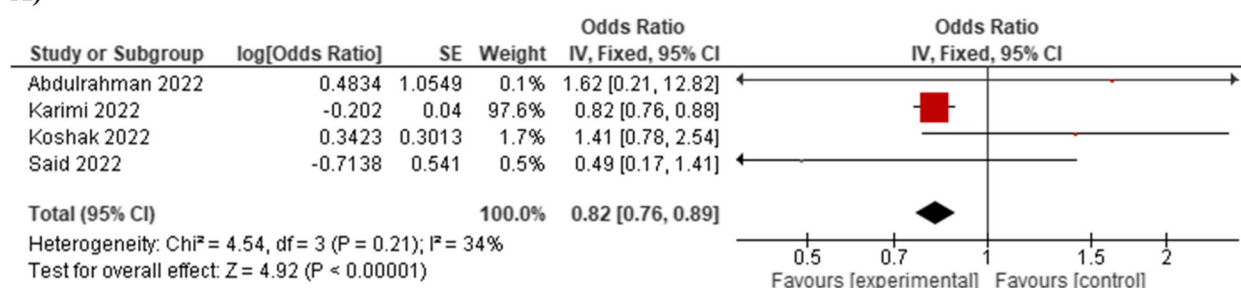


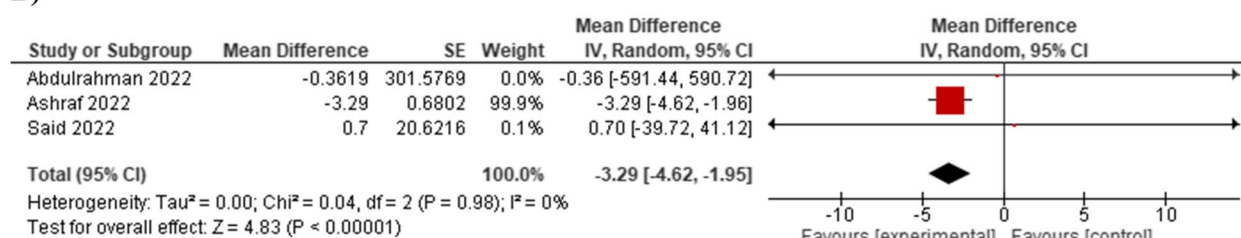
Fig. 2 Risk of bias summary and graph

In a double-blinded, randomized controlled trial that evaluated the effects of *Nigella sativa* on mild COVID-19 patients, participants were divided into seven subgroups. Each subgroup received varying dosages of whole or powdered *Nigella sativa* seeds or a placebo in charcoal capsules [5]. The results revealed no significant variances in symptoms, differentiation profile, or inflammatory markers among the groups. This finding contrasts with existing literature indicating its anti-inflammatory effects [9]. The trial's relatively brief duration of ten days could

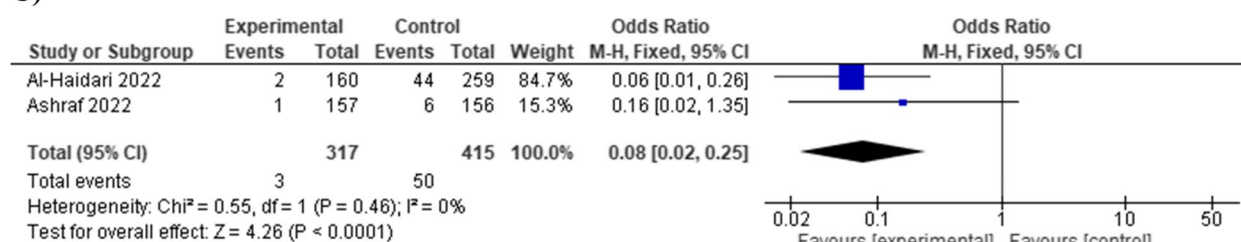
A)



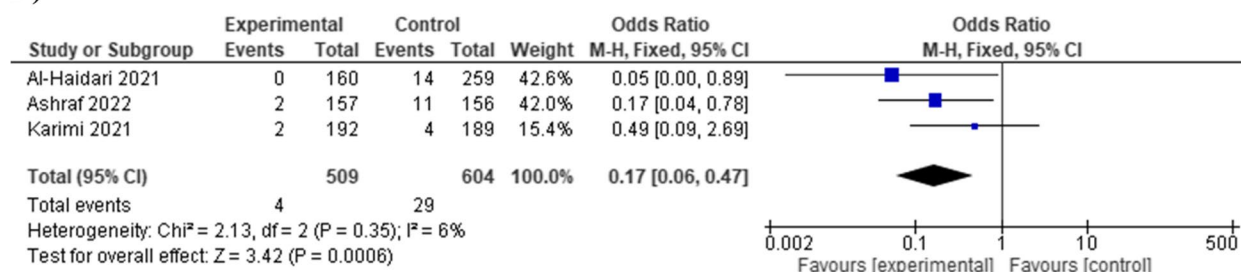
B)



C)



D)

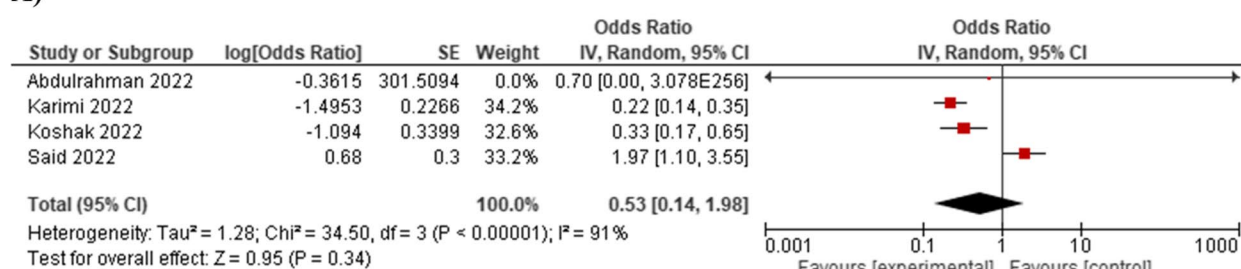
**Fig. 3** Forest plots of meta-analysis of **A** Headache, **B** CRP levels, **C** Severity, **D** Mortality rates

potentially explain this discrepancy, as studies assessing the impacts of natural products often span 4–12 weeks (E. M. [30, 36]). Evidently, a separate trial involving COVID-19 patients indicated significant gastrointestinal adverse events, including nausea and diarrhea, upon ingestion of *Nigella sativa* capsules, even though patients also showed symptom improvements [12].

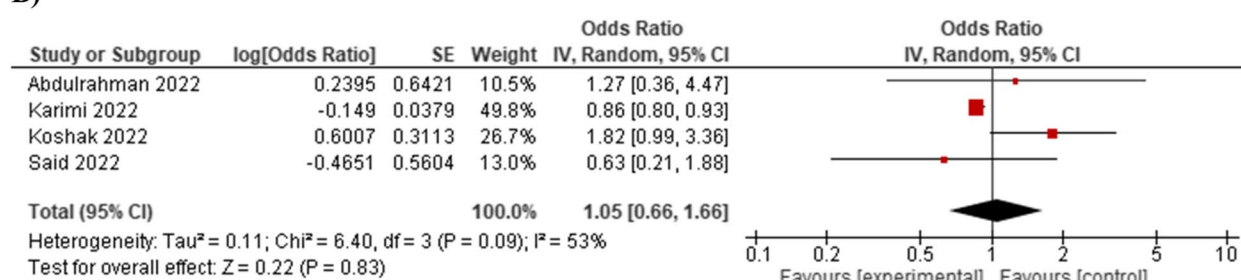
Interestingly, when combined with honey, *Nigella Sativa* demonstrates a marked increase in therapeutic efficacy for COVID-19 patients [3], resulting in a 50% reduction in symptom duration, accelerated viral clearance in both moderate and severe cases, and presented enhanced clinical outcomes by day six. Specifically, 63.6%

of moderate cases resumed typical activities, contrasting with 10.9% in the control cohort. In the severe category, 50% were discharged from hospital settings, compared to a mere 2.8% from the placebo group. The heightened therapeutic outcomes can be attributed to the combined constituents' collective efficacy, rather than isolated effects. Key components in Honey and *Nigella sativa* (HNS)—including flavonoids/phenolic/fatty acid—are posited to impede the viral infection process through binding to the interface between virus spike protein and receptor [38]. Concurrently, literature verifies this combination's dual antioxidant [15] and antimicrobial

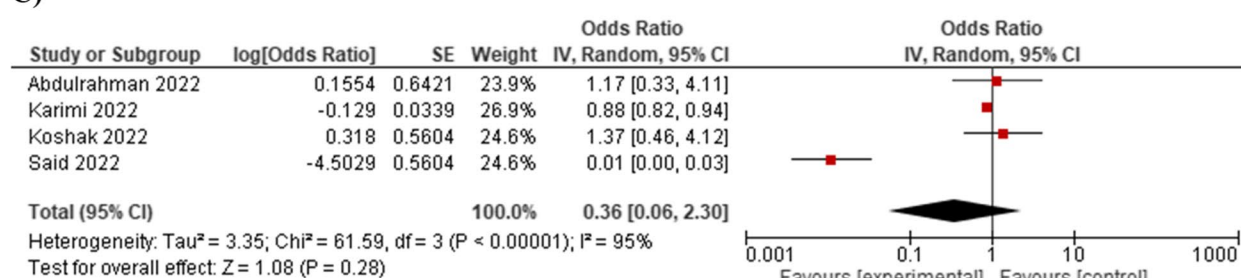
A)



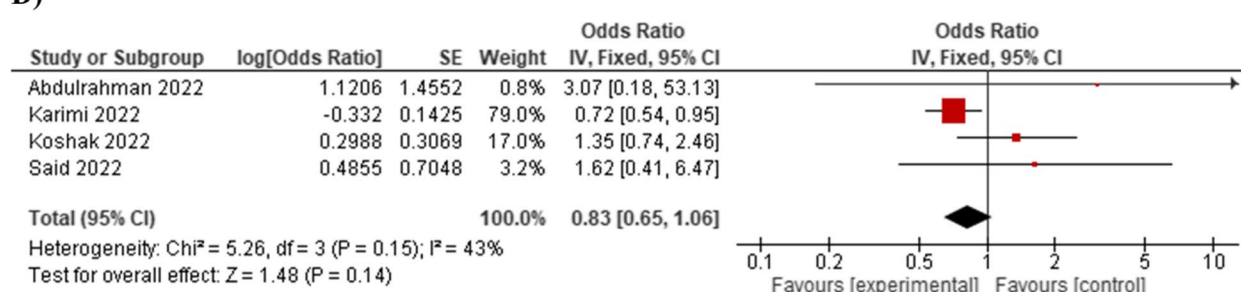
B)



C)



D)



E)

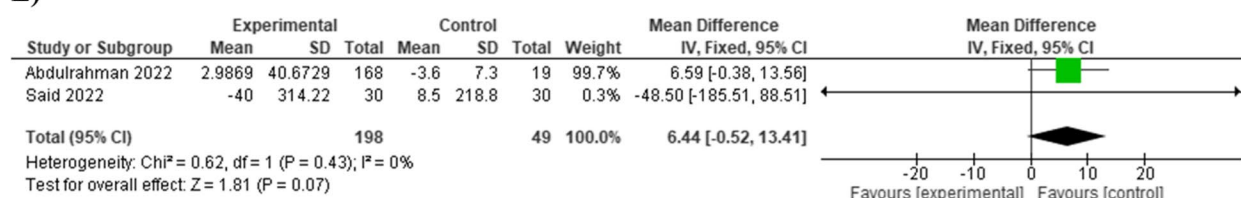


Fig. 4 Forest plots of meta-analysis of **A** Fever, **B** Cough, **C** Fatigue, **D** Rhinorrhea, **E** Ferritin levels

properties [10], and can also improve pulmonary function without exhibiting hepato-renal toxicity [24].

Further investigations revealed that combining *Nigella sativa* with vitamin D3 is similarly more efficacious than standard treatments in mitigating COVID-19 symptoms by expediting viral clearance and reducing concentrations of pro-inflammatory cytokines [29]. Additionally, it demonstrates protective measurements against acute lung injury and acute respiratory failure, both of which are formidable complications associated with severe COVID-19 cases. Moreover, integrating herbal interventions with standard care has significantly reduced hospitalization duration and expedited clinical recovery compared to standard care alone. This combined therapeutic strategy can potentially optimize patient recovery, alleviate pressures on healthcare systems, and streamline patient management during critical pandemic situations [12, 16].

Strengths and limitations

Our meta-analysis adheres to the PRISMA checklist and, to the best of our knowledge, is the most comprehensive meta-analysis to assess the effect of *Nigella sativa* on clinical outcomes and inflammatory markers in COVID-19 patients. Further, the consistent findings among included studies with homogeneity in most outcomes strengthen the validity and reliability of our results. Studies also demonstrated a low risk of bias. However, the small number of included studies, along with the small sample size, may present a limitation of our study. Publication bias was not assessed, and meta-regression was not conducted due to the limited number of studies. Different follow-up periods in the included studies might make comparing the studies more challenging. Additionally, most of the included studies were from the Middle East and Pakistan, highlighting that the regional concentration of studies may limit generalizability.

Conclusion

Our meta-analysis shows that adding *Nigella sativa* as a treatment option for COVID-19 patients appears to yield therapeutic benefits by lowering mortality rates with significantly lower CRP levels, reducing the likelihood of headaches, and mitigating severe infection symptoms. However, typical COVID-19 symptoms showed no statistically significant effects. These results should be interpreted in light of the limitations of the existing literature and emphasize the need for more studies.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1007/s44467-025-00004-7>.

Supplementary Material 1.

Acknowledgements

None.

Protocol and prospective registration

This meta-analysis followed PRISMA guidelines and was prospectively registered in PROSPERO (CRD42023449783).

Authors' contributions

Conceptualization, Methodology: Amr Elrosasy; Project administration: Amira Mohamed Taha, Amr Elrosasy; Formal analysis and investigation: Amr Elrosasy; Data Curation: Rashad G. Mohamed, Islam Omar, Fatmaelzahraa Yasser Ali, Mohamed Elbanna; Writing—original draft preparation: Amira Mohamed Taha, Dang Nguyen, Nouran Ahmed Taha, Shirin Cadri; Writing—review and editing: Amira Mohamed Taha, Moaz Elsayed Abouelmagd.

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Data availability

All data were extracted from published articles included in this review. The complete extraction sheet and analysis files (RevMan) are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Competing interests

The authors declare no competing interests.

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