

Corticosteroids in critically ill patients with community-acquired pneumonia: A systematic review and Bayesian meta-analysis

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ABSTRACT

Introduction: This systematic review and meta-analysis aimed to evaluate the effectiveness and safety of adjunct systemic corticosteroid therapy in patients admitted to the intensive care unit (ICU) with bacterial community-acquired pneumonia (CAP).

Method: We searched MEDLINE, Embase and the Cochrane Library to identify randomised controlled trials (RCTs) published from the databases' inception to February 2024. All RCTs evaluating the effect of systemic corticosteroids on mortality, compared to standard of care among adult bacterial CAP patients admitted to ICU were included. Bayesian meta-analysis was conducted in line with the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines. Independent authors reviewed each study for eligibility, extracted data and assessed risk of bias in duplicate, with discrepancies referred to senior reviewers.

Results: A total of 6 RCTs comprising 1585 patients were included for analysis. In ICU patients with severe CAP who were treated with corticosteroids, there was no significant reduction in hospital mortality (risk ratio [RR] 0.70, 95% confidence interval [CI] 0.39–1.14, certainty of evidence: ⊕⊕⊖⊖ low) or all-cause mortality (RR 0.68, 95% CI 0.34–1.22, ⊕⊕⊖⊖ low) compared with placebo. The use of corticosteroids showed a significant reduction in mechanical ventilation post-intervention (RR 0.58, 95% CI 0.37–0.86, ⊕⊕⊕⊕ high) compared with placebo. In a subgroup analysis of patients treated with hydrocortisone, hospital mortality was significantly reduced (RR 0.45, 95% CI 0.20–0.88, ⊕⊕⊖⊖ low) compared with placebo. There was no significant increase in gastrointestinal bleeding, secondary infections or hyperglycaemia in patients treated with corticosteroids.

Conclusion: Corticosteroids significantly reduced mechanical ventilation requirements, and hydrocortisone significantly reduced hospital mortality. Further work is required to determine whether other corticosteroids reduce mortality among ICU patients with CAP.

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Keywords: Bayesian meta-analysis, community-acquired pneumonia, corticosteroids, critically ill, ICU, mortality

CLINICAL IMPACT

What is New

- Corticosteroids significantly reduced mechanical ventilation and hydrocortisone significantly reduced hospital mortality in patients with community-acquired pneumonia (CAP) who required admission to the intensive care unit (ICU).
- There was no significant increase in gastrointestinal bleeding, secondary infections or hyperglycaemia in patients treated with corticosteroids compared with patients given placebo.

Clinical Implications

- Our findings support the Society of Critical Care Medicine guidelines on the use hydrocortisone.
- This study also highlights the need for future studies to determine whether other corticosteroids reduce mortality among ICU patients with CAP and inform priors for future Bayesian studies.

INTRODUCTION

Community-acquired pneumonia (CAP) is a common cause of hospital mortality. Each year, in the US alone, more than 1.5 million pneumonia patients

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are hospitalised, and 1 in 3 of them die within 1 year.¹ Mortality is the highest among patients requiring organ support in the intensive care unit (ICU). These patients meet the definition of sepsis, where a dysregulated immune response to infection has resulted in life-threatening organ dysfunction. If sustained hypotension occurs, they would meet the definition of septic shock.² For the past 20 years, Surviving Sepsis Campaign guidelines have recommended using corticosteroids in patients with septic shock because these have been demonstrated to reduce mortality.^{3,4} However, although the rate of mortality of CAP patients admitted to the ICU is similar to those seen in those with septic shock, the use of steroids in the former group remains controversial, highlighted by divergent results reported in the 2 largest studies to date. The Extended Steroid in Use in Community Acquired Pneumonia (ESCAPE, NCT01283009) trial by Meduri et al. found no significant mortality benefit whereas the Community-Acquired Pneumonia: Evaluation of Corticosteroids (CAPE COD, NCT02517489) trial by Dequin et al. demonstrated a significant 5.6% reduction in mortality with the use of corticosteroids.^{5,6} Despite this, the updated 2024 guidelines by the Society of Critical Care Medicine (SCCM) strongly recommended corticosteroids in patients with severe bacterial CAP.⁷

We performed a comprehensive systematic review and Bayesian meta-analysis to complement the recent SCCM guidelines, and evaluated the effectiveness and safety of adjunct systemic corticosteroid therapy in patients admitted to the ICU with bacterial CAP. Bayesian inference is common in clinical reasoning; clinicians make decisions by weighing pre-existing information with new evidence.^{8,9} Bayesian methods can be used in systematic reviews, allowing us to assess how the probability of the intervention's effectiveness has evolved with new data.

METHOD

This systematic review and meta-analysis adhered to the reporting guidelines of Preferred Reporting Items for Systematic Reviews and Meta-analyses.¹⁰ The study protocol was registered with PROSPERO (CRD42023451607).

Information source and search strategy

A systematic search was conducted in 3 databases: MEDLINE (using the PubMed platform), Embase and the Cochrane Library, using Medical Subject Headings (MeSH) and keywords. Keywords and MeSH terms synonymous with "corticosteroids" and "community-acquired pneumonia" formed the basis of the search strategy. The reference list

of relevant published articles was hand searched for relevant trials. The search included articles from inception of the databases to February 2024. Only full-text articles published in the English language were included. The full search strategy and search terms are included in the Supplementary Table S1. References were imported into EndNote X9 (The EndNote Team, Clarivate, Philadelphia, US) for the initial removal of duplicates.

Eligibility criteria

All randomised controlled trials (RCTs) evaluating adjunctive systemic corticosteroids compared with the standard of care regarding mortality among adult bacterial CAP patients in ICU were considered eligible. Data from non-peer-reviewed articles, conference proceedings or abstract presentations were excluded. We excluded trials involving paediatric populations, hospital-acquired pneumonia, viral pneumonia, aspiration pneumonia, patients with septic shock at randomisation and patients on long-term steroids (Fig. 1).

Primary and secondary outcomes

Hospital mortality was selected as the primary outcome. ICU mortality was used when hospital mortality was not reported. Secondary outcomes included all-cause mortality, mechanical ventilation requirement, secondary infections, hyperglycaemia and gastrointestinal bleeding.

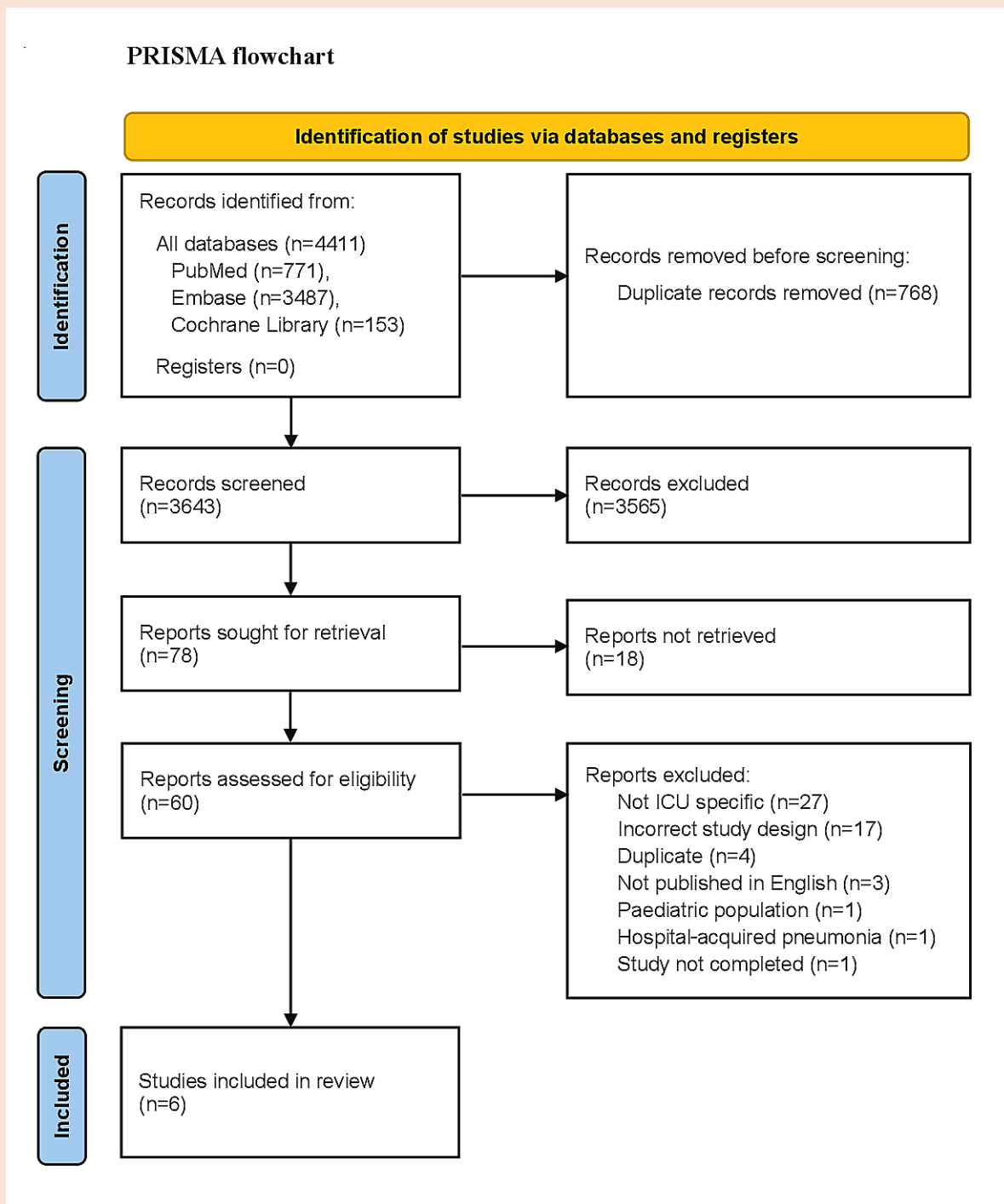
Study selection and data extraction

Four investigators independently screened titles and abstracts to identify potentially eligible studies (authors WYC, NC, SCI and RG) and independently assessed full-text copies for inclusion. Senior reviewers (MC and JS) were consulted to reach a consensus. The same 4 investigators independently extracted information from the RCTs, including authors, publication year, study site, clinical trial number, recruitment period, corticosteroid dosage and duration, age and sex, sample size, and withdrawals. Discrepancies were resolved by senior reviewers (MC and JS).

Risk of bias and certainty of evidence assessment

Risk of bias was assessed using the Cochrane risk-of-bias 2.0 tool.¹¹ Four investigators (WYC, NC, SCI, and RG) independently reviewed the included studies. They rated the studies as having "low risk," "some concerns" or "high risk" of bias based on the randomisation process, deviations from intended interventions, missing outcome data, measurement of outcome and selection of reported result. Senior reviewers (MC and JS) were consulted to resolve disagreements.

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flowchart.



ICU: intensive care unit

Certainty of evidence was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach.¹² We defined the levels of evidence as “high”, “moderate”, “low” or “very low” based on the risk of bias, indirectness of evidence (population, intervention, control and outcomes), unexplained heterogeneity, inconsistent results and probability of publication bias. A summary of the findings for

assessing the certainty of the evidence for each outcome is available in Supplementary Table S3.

Data analysis

Bayesian meta-analysis was conducted using R version 4.3.2 (R Core Team, Vienna, Austria) with vague priors (log of the risk ratio [RR] assumed to have a normal distribution with a mean of 0 and a standard deviation of 2). The random effects

model was used to estimate the pooled RRs and their corresponding 95% confidence intervals (CI). An RR <1 indicated that corticosteroids had a lower risk of outcomes. The proportion of variability due to heterogeneity was assessed using the I^2 statistic, and an I^2 statistic of $\geq 50\%$ was considered significant. We also reported frequentist meta-analysis data using Review Manager 5.4.1 software (Cochrane Collaboration, London, UK).

RESULTS

The search strategy identified 4411 articles across all 3 databases, of which 768 were duplicate studies and excluded. Among the remaining 3643 articles, 3565 were excluded after title and abstract screening. The final 60 articles underwent full-text screening, and 6 studies were deemed eligible for inclusion and final analysis. The baseline characteristics of the included studies are summarised in Table 1. The 6 studies were double-blind RCTs, with 1585 patients and mortality reported in 1573 patients. Among these 1573 patients, 793 (50.4%) were allocated to receive adjunctive systemic corticosteroids and 780 (49.6%) received placebo. The type of corticosteroids varied: intravenous (IV) hydrocortisone was used in 4 trials,^{5,13–15} IV methylprednisolone in 1 trial⁶ and IV prednisone in 1 trial,¹⁶ with treatment duration ranging from 1 to 20 days.

Primary outcome: hospital mortality

All 6 included studies reported hospital mortality. Other mortality timepoints used in the studies include 8-day,¹⁵ 28-day⁵ and 60-day mortality.⁶ Hospital mortality rates within the corticosteroid group ranged from 0%¹³ to 52%,¹⁶ with an overall mortality rate of 9.4%. In contrast, the control group reported an overall mortality rate of 13.4%, ranging from 9.8%⁶ to 60%.¹⁶ In patients who were given any corticosteroid, there was no significant reduction in hospital mortality (RR 0.70, 95% CI 0.39–1.14, GRADE certainty of evidence: $\oplus\oplus\ominus\ominus$), with a 94.2% posterior probability that corticosteroids reduced hospital mortality (Fig. 2). The certainty in the evidence was low (Supplementary Table S3). In patients who received prednisone/methylprednisolone, hospital mortality was similar to the placebo group (RR 1.01, 95% CI 0.52–1.94, $\oplus\oplus\ominus\ominus$) with a 48.1% posterior probability that prednisone/methylprednisolone reduced hospital mortality. In trials where patients were given hydrocortisone, hospital mortality was significantly reduced (RR 0.45, 95% CI 0.20–0.88, $\oplus\oplus\ominus\ominus$), with a 99.0% posterior probability for reduced hospital mortality (Fig. 3). The frequentist method sensitivity analyses demonstrated similar findings (Supplementary Fig. S1).

Secondary outcomes

All-cause mortality was reported in 3 trials.^{5,6,15} In patients given any corticosteroid, there was no significant reduction in all-cause mortality (RR 0.68, 95% CI 0.34–1.22, $\oplus\oplus\ominus\ominus$), with 93.1% posterior probability that corticosteroids reduced all-cause mortality (Fig. 4A). The need for mechanical ventilation after randomisation was reported in 5 trials. We found that corticosteroid use was associated with a significant reduction in mechanical ventilation post-intervention compared to placebo (RR 0.58, 95% CI 0.37–0.86 $\oplus\oplus\oplus\oplus$), with 99.2% posterior probability that corticosteroids reduced mechanical ventilation requirement (Fig. 4B). Sensitivity analyses using the frequentist method produced similar findings (Supplementary Fig. S1).

The incidence of gastrointestinal bleeding was reported in 4 studies, and we found no significant increase in gastrointestinal bleeding in patients who were given corticosteroid therapy (RR 1.00, 95% CI 0.47–2.16, $\oplus\oplus\ominus\ominus$) (Fig. 4C). Five studies reported on secondary infections; there was no significant increase in secondary infections in patients who were given corticosteroid therapy compared to placebo (RR 0.66, 95% CI 0.28–1.12 $\oplus\oplus\ominus\ominus$) (Fig. 4D). Only 1 study reported hyperglycaemia; no significant increase was found in patients who received corticosteroids compared to placebo (RR 1.33, 95% CI 0.46–3.72, $\oplus\oplus\oplus\ominus$) (Fig. 4E).

Risk-of-bias assessment

Three trials were adjudicated as having a low risk of bias in all domains, and the risk of bias was adjudicated as low for all trials that reported data on hospital mortality (Supplementary Table S2). We also rated the certainty of evidence in other outcomes due to the risk of bias, as shown in Supplementary Table S2.

DISCUSSION

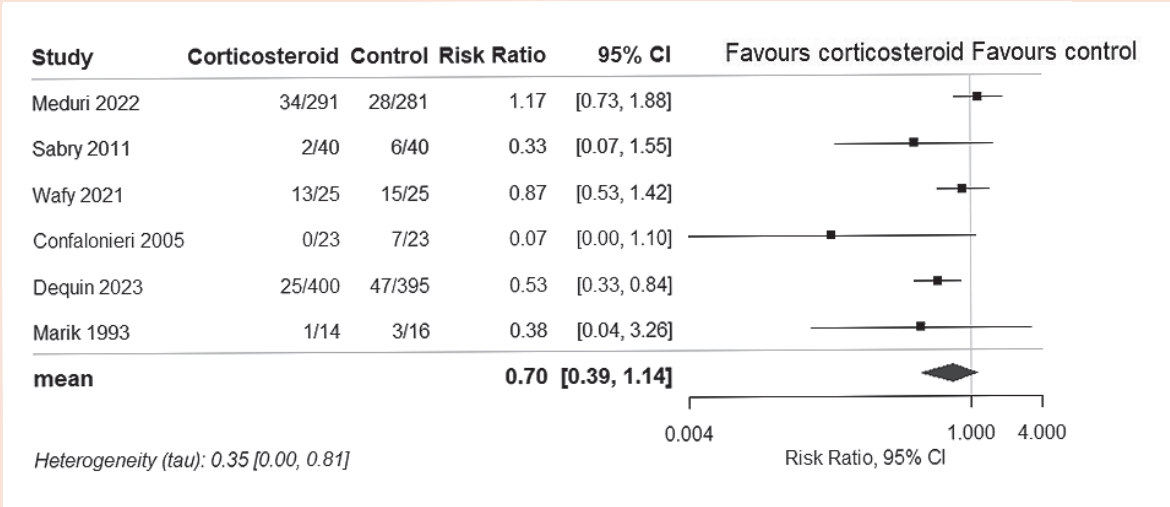
We conducted a comprehensive systematic review and Bayesian meta-analysis to evaluate the effectiveness of corticosteroids in ICU patients with CAP, eventually including 6 RCTs with a total of 1585 patients. We found no significant difference in hospital mortality (RR 0.70, 95% CI 0.39–1.14, $\oplus\oplus\ominus\ominus$) and all-cause mortality (RR 0.68, 95% CI 0.34–1.22, $\oplus\oplus\ominus\ominus$), with a posterior probability of 94.3% and 93.1% that corticosteroids were associated with lower hospital mortality and all-cause mortality, respectively. A subgroup analysis found that the type of corticosteroid may be important; hydrocortisone use demonstrated a significant reduction in hospital mortality (RR 0.45, 95% CI 0.20–0.88, $\oplus\oplus\ominus\ominus$), which was not seen in studies using prednisone/methylprednisolone

Table 1. Baseline characteristics of included studies.

Author, year, country	Study centres	Sample			Type of corticosteroid	Treatment duration	Dosing strategy
		Total	Control group	Steroid group			
Meduri, 2022, US ⁶	42	584	287	297	Methylprednisolone	20 days	Methylprednisolone for 20 days. Loading dose 40 mg followed by maintenance infusion on day 0; 40 mg/day on days 1–7. 20 mg/day on days 8–14; 12 mg/day on days 15–17; 4 mg/day on days 18–20.
Sabry, 2011, Egypt ¹⁵	3	80	40	40	Hydrocortisone	7 days	Hydrocortisone for 7 days. Loading dose 200 mg over 30 minutes followed by 300 mg in 500 mL 0.9% saline (rate 12.5 mg/hr) for 7 days.
Wafy, 2021, Egypt ¹⁶	1	50	25	25	Prednisone	7 days	Prednisone for 7 days; 40 mg/day.
Confalonieri, 2005, Italy ¹³	6	46	23	23	Hydrocortisone	7 days	Hydrocortisone for 7 days. Loading dose 200 mg followed by 240 mg in 500 mL 0.9% saline (rate 10 mg/hr) for 7 days.
Dequin, 2023, France ⁵	31	795	395	400	Hydrocortisone	8/14 days	Hydrocortisone for 8 or 14 days. Dose 200 mg/day for first 4 days. On day 4, medical team used predefined criteria to decide whether to administer hydrocortisone for total 8 or 14 days, depending on whether patient's condition improved.
Marik, 1993, South Africa ¹⁴	1	30	16	14	Hydrocortisone	1 day	Hydrocortisone for 1 day. Single dose of 10 mg/kg 30 minutes prior to commencing antibiotic therapy.

Superscript numbers: refer to REFERENCES

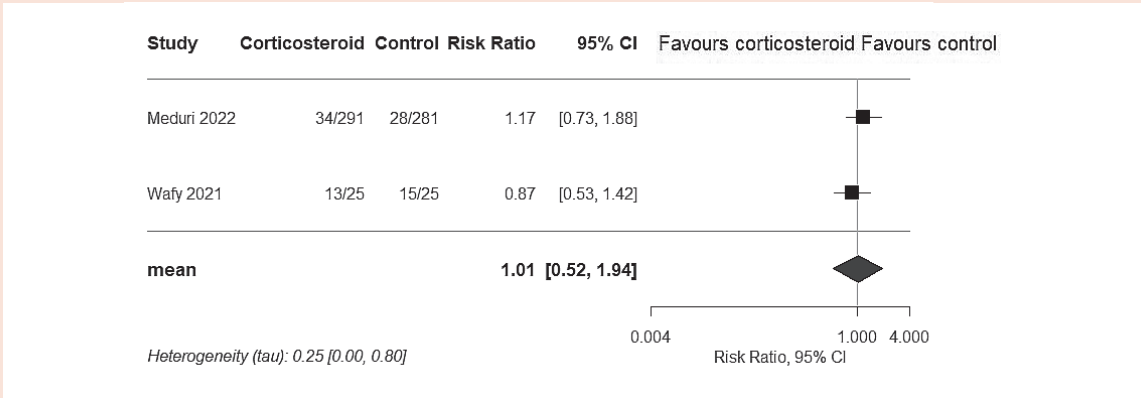
Fig. 2. Forest plot on hospital mortality for the comparison between the outcome of adjuvant systemic corticosteroids and placebo using Bayesian analysis. There was 94.3% posterior probability that corticosteroid was associated with reduced hospital mortality.



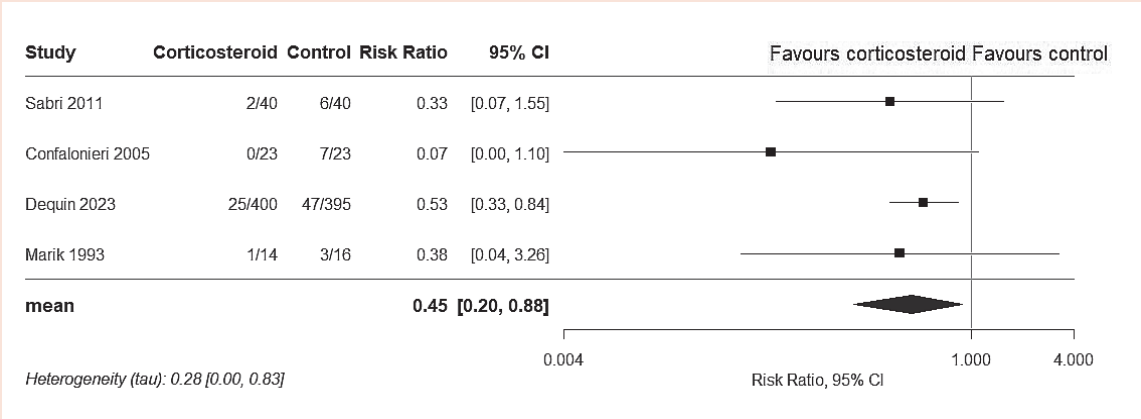
CI: confidence interval

Fig. 3. Forest plot on hospital mortality based on corticosteroid subtype, (A) prednisone/methylprednisolone and (B) hydrocortisone for the comparison between adjuvant systemic corticosteroids and placebo using Bayesian analysis.

(A) Prednisone/methylprednisolone: there was a 48.1% posterior probability that corticosteroid was associated with reduced hospital mortality.



(B) Hydrocortisone: there was a 99.0% posterior probability that corticosteroid was associated with reduced hospital mortality.



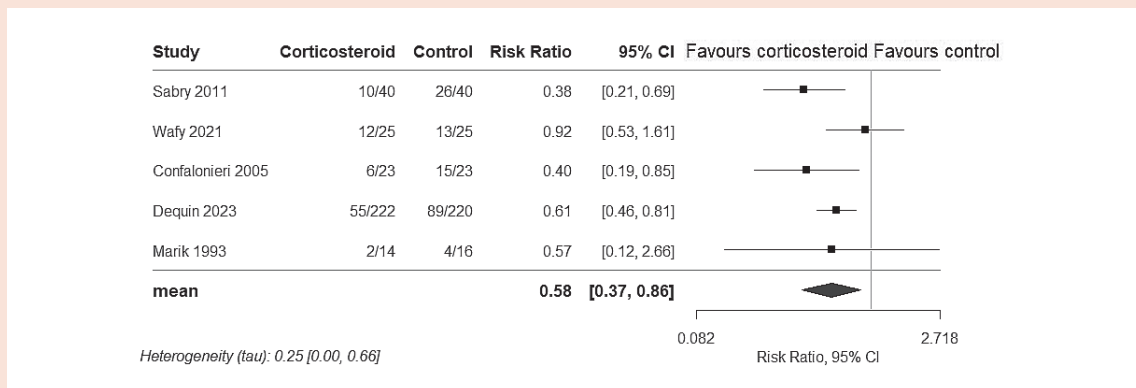
CI: confidence interval

Fig. 4. Forest plot on (A) all-cause mortality, (B) mechanical ventilation post intervention, (C) gastrointestinal bleeding, (D) secondary infections and (E) hyperglycaemia for the comparison between the outcome of adjuvant systemic corticosteroids and placebo using Bayesian analysis.

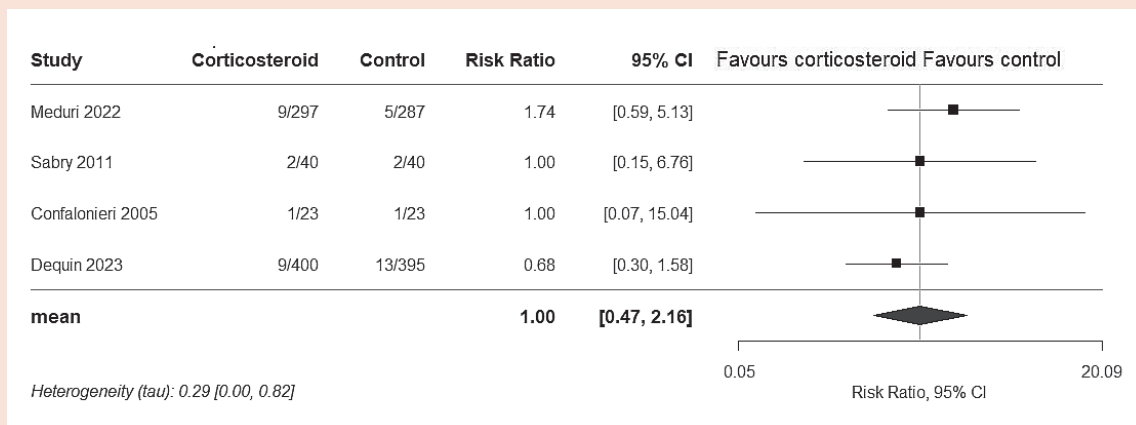
(A) All-cause mortality: there was a 93.1% posterior probability that corticosteroid was associated with reduced mortality.



(B) Mechanical ventilation: there was a 99.2% posterior probability that corticosteroid was associated with reduced risk of mechanical ventilation.



(C) Gastrointestinal bleeding: there was a 50.2% posterior probability that corticosteroid was associated with reduced risk of gastrointestinal bleeding.



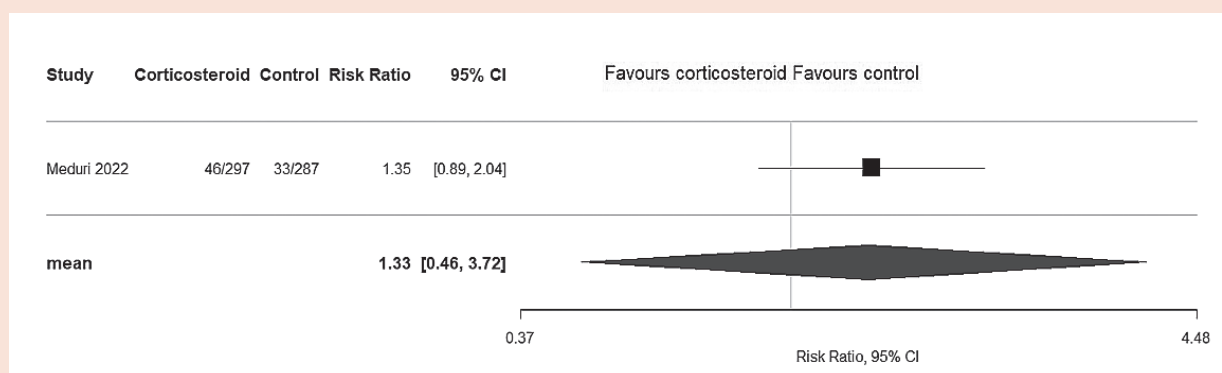
(RR 1.01, 95% CI 0.52–1.94, ⊕⊕⊕⊕). We also found that patients receiving corticosteroids were significantly less likely to require mechanical ventilation, and their use was not associated with any significant increase in the risk of hyperglycaemia, gastrointestinal bleeding or secondary infections.

Literature on the use of corticosteroids for CAP parallels that of septic shock because in the past, corticosteroids had not always been recommended for patients with septic shock in sepsis guidelines.⁴ Studies conducted before the 2000s produced conflicting results,¹⁷ and it was not until Annane

- (D) Secondary infections: there was a 95.6% posterior probability that corticosteroid was associated with reduced risk of secondary infections.



- (E) Hyperglycaemia: there was a 22.8% posterior probability that corticosteroid was associated with reduced risk of hyperglycaemia.



CI: confidence interval

et al.'s multicentre RCT in 2002,¹⁸ supported by subsequent meta-analysis, that the practice of corticosteroid therapy in septic shock was firmly established in guidelines.¹⁹ Although uncertainties reemerged in 2008 when a second multicentre RCT failed to demonstrate a mortality benefit with corticosteroids,²⁰ a subsequent meta-analysis reinforced the evidence that corticosteroids reduce mortality in patients with refractory septic shock. More recently, corticosteroids have been recommended in patients with acute respiratory distress syndrome (ARDS),⁷ and in 2024, SCCM guidelines recommended corticosteroids for adults with severe bacterial CAP.⁷ Before these recommendations, patients with CAP typically only received steroids if they had concurrent, refractory septic shock.^{4,17} This may reflect that certain illness severity thresholds need to be reached before patients benefit from corticosteroids. Since CAP mortality in ICU patients is similar to that for septic shock,²¹⁻²⁴ it is logical to investigate the role of corticosteroids in CAP.

Interest in the role of corticosteroids in CAP was further renewed with the publication of the recent

large RCT by Dequin et al., which concluded that corticosteroids significantly improved mortality in patients with CAP admitted to ICU, contrary to prior studies and meta-analyses.⁵ Therefore, we conducted this Bayesian meta-analysis to determine if this latest trial changes the conclusions of earlier meta-analysis. Our study found no significant decrease in hospital mortality rate with corticosteroid use (RR 0.70, 95% CI 0.39–1.14, ⊕⊕⊕⊕), while the posterior probability of 94.3% suggests—without meeting statistical significance—that corticosteroids are more likely than not to be beneficial, which encourages further investigation.

In contrast, a recent meta-analysis by Wu et al. which investigated the role of corticosteroids in severe CAP, included 7 studies (1689 patients) and concluded that corticosteroids significantly reduced 30-day mortality compared to the placebo.²⁶ Our study may have drawn different conclusions because we defined severe CAP as requiring ICU admission, whereas Wu et al. defined severe CAP more broadly using the American Thoracic Society/Infectious Diseases Society of America criteria, the Pneumonia Severity Index or ICU admission.^{25,26} As a result, they

included a study by Torres et al., a multicentre trial in Spain that recruited 120 hospitalised pneumonia patients for treatment with methylprednisolone or placebo. However, only 70% of the patients were admitted to ICU and the outcomes for ICU patients were not reported separately, thus excluding this study from our analysis. In addition, Wu et al. included an ICU study by El-Ghamrawy et al. for which we were unable to retrieve the full text. We decided not to extract data for this study from other meta-analysis because we could not independently assess the quality of the study. Our application of Bayesian methods is unlikely to explain why Wu et al. drew a different conclusion, because our findings are similar using a frequentist analysis (Supplementary Fig. S1). Notably, both studies by Meduri et al. and Dequin et al. included the 2 largest trials accounting for 1379 patients, i.e. more than 80% of the total patients in both meta-analyses.^{5,6}

The choice of corticosteroid may be important. Our subgroup analysis of hydrocortisone use found a statistically significant decrease in hospital mortality; this reduction was not seen with prednisone/methylprednisolone use. Differences in pharmacological properties might explain this; hydrocortisone has higher mineralocorticoid activity than prednisone and methylprednisolone.²⁷ In large animal sepsis models, mineralocorticoid levels were inversely correlated with the severity of shock and mortality; adding mineralocorticoids reversed this.²⁸ Our hydrocortisone sub-analysis does support the current 2024 SCCM guidelines and aligns with the conclusions of Wu et al. provided that hydrocortisone is the corticosteroid used. A large international study, the Randomized Embedded Multifactorial Adaptive Platform for Community-acquired Pneumonia (REMAP-CAP, NCT02735707) is currently studying hydrocortisone in severe CAP, and their findings will help add to existing data on hydrocortisone.

The benefits of corticosteroids may extend beyond mortality. We found that corticosteroids were associated with a significant decrease in the mechanical ventilation requirement, similar to other studies.^{25,26} Reducing the need for mechanical ventilation has considerable resource implications but it also protects patients from the potentially harmful effects of mechanical ventilation itself. It is an important finding because the need for mechanical ventilation in CAP predicts increased mortality (odds ratio 18.4, 95% CI 8.65–39.1, $P < 0.001$).²⁹ Since our meta-analysis included only randomised, double-blind trials, our findings are unlikely to be influenced by the clinician's knowledge of which intervention the patient received. It is plausible that patients who had received corticoste-

roids had higher $\text{PaO}_2/\text{FiO}_2$ ratios; this effect of steroids has been reported in ARDS patients,³⁰ which reduced the perceived need for mechanical ventilation. Additionally, by reducing inflammation in CAP, steroids may modify the hypermetabolic state by reducing the work of breathing, lactic acid production and CO_2 production,³⁰ again reducing the requirement for mechanical ventilation.

A sensible hypothesis for why the reduced requirement for mechanical ventilation did not translate to a mortality benefit could be the offset of any benefit by harmful steroid side effects, such as the increased risk of infection, hyperglycaemia and gastrointestinal tract bleeding. However, our meta-analysis found no association between corticosteroid usage and secondary infections (RR 0.66, 95% CI 0.28–1.12, $\oplus\oplus\ominus\ominus$). The risk of secondary infection is lower with shorter courses,³¹ and in our meta-analysis, corticosteroid therapy was limited (7 days to 20 days, Table 1).^{5,6,13,15,16} The ICU context may influence this too, since patients are often individually isolated, limiting opportunities for cross-patient and airborne contamination.^{26,32}

Drug-induced hyperglycaemia is a common consequence of corticosteroid use.³³ Interestingly, we found no association between corticosteroid use and hyperglycaemia requiring insulin, perhaps because hyperglycaemia is frequently encountered in critically ill patients, regardless of corticosteroid use.⁶ However, patients receiving corticosteroids required higher insulin doses,^{5,34} though this could be beneficial since insulin use reduces circulating free fatty acids and improves myocardial glucose uptake, thus enhancing myocardial function and systemic circulation.³⁵

We also found that corticosteroid use was not associated with an increased risk of gastrointestinal bleeding. This side effect concerns clinicians, even though robust meta-analyses have suggested that it is not as common as perceived.³⁶ Corticosteroids did reduce the biosynthesis of gastric mucous, bicarbonate and cytoprotective prostaglandins, but these effects may be counterbalanced by suppressed production of gastric-damaging leukotrienes.³⁷ Furthermore, proton pump inhibitors or histamine H₂ receptor antagonists are commonly started in patients admitted to ICU.

In this study, we applied the Bayesian methods as our primary form of analysis. Unlike the frequentist methods, Bayesian analysis incorporates prior beliefs and knowledge about parameters,³⁸ allowing integration of existing knowledge, which helps to improve the accuracy and reliability of the predictions³⁹ and more closely reflects clinical decision-making at the bedside. Furthermore, Bayesian analysis provides a 95% probability of

the true effect of corticosteroids. In our study, the overall posterior probability of 94.3% suggests steroids are more likely than not to improve mortality, without meeting statistical significance. This can inform priors in future Bayesian studies and encourages continued investigation of the effect of corticosteroids in these patients. Future studies should focus on comparing the efficacy of different corticosteroids in these patients and attempt to identify subphenotypes that are more likely to benefit. For example, in COVID-19 pneumonia, corticosteroids were associated with mortality benefit in patients with a hyperinflammatory phenotype, and harm in those with hypoinflammatory phenotypes.^{40,41}

Several limitations deserve consideration. First, we could not analyse other important side effects of corticosteroids such as neuropsychiatric and electrolyte disturbances due to insufficient data. Second, we only identified 6 RCTs for final inclusion, not only reflecting the challenges of conducting high-quality RCTs but also exposing our results to the risk of being driven by the 2 largest studies. Third, there is evidence of heterogeneity because the inclusion criteria to determine ICU admission differed slightly across the studies. Four RCTs used the American Thoracic Society criterion,^{6,13,15,16} 1 used the British Thoracic Society criterion for severe pneumonia¹⁴ and another used the Pulmonary Severity Index.⁵ Adding to heterogeneity of evidence, primary outcomes investigated were not standardised across studies.

CONCLUSION

After conducting our Bayesian analysis, we found that current evidence does not support the conclusion that corticosteroids significantly reduce mortality in bacterial CAP. Nevertheless, the posterior probability of effect is >90%, and a subgroup analysis found that hydrocortisone significantly reduced mortality. Importantly, the use of adjunct corticosteroids reduced the need for mechanical ventilation and was reported as safe, thus encouraging future efforts to study this therapy. Our findings support the 2024 SCCM guidelines on the use hydrocortisone.

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Disclosure

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no affiliations or financial involvement with any commercial organisation with a direct financial interest in the subject or materials discussed in the manuscript.

Supplementary materials

Fig. S1. Frequentist analysis of primary and secondary outcomes.

Table S1. Detailed search strategy.

Table S2. Risk-of-bias assessment.

Table S3. Certainty of evidence.

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