Life-threatening hemorrhage after trauma is a globally relevant source of premature death and disability. Patients often receive large volumes of fractionated blood products to support organ perfusion and hemostasis, but the ideal ratios of these blood products are unknown. The Pragmatic Randomized Optimal Platelet and Plasma Ratios (PROPPR) trial was a randomized trial that compared transfusion of plasma, platelets, and red cells using a ratio of 1:1:1, as opposed to 1:1:2. There was no significant difference in the primary outcomes of 24-hour and 30-day mortality. These results have caused significant controversy. Proponents of the 1:1:1 strategy have pointed to secondary outcomes (achieving hemostasis) to support its ongoing use, while others observed that the primary statistical conclusion of no benefit allows for use of a 1:1:2 strategy.

Given the ongoing relevance and uncertainty of the optimal transfusion strategy in patients with life-threatening hemorrhage after trauma, Lammers et al performed a post-hoc bayesian reanalysis of the PROPPR trial. Using this bayesian approach, they determined that the probability that 1:1:1 was superior to 1:1:2 was 94% with respect to 24-hour mortality and 86% with respect to 30-day mortality. Lammers et al used bayes factors to show that the 1:1:1 strategy, as opposed to 1:1:2 strategy, was 15.5 times more likely to result in lower 24-hour mortality, and 6.2 times more likely to result in lower 30-day mortality. These results differ from a frequentist interpretation of no benefit and help to strengthen the evidence base underlying guideline recommendations for a balanced transfusion strategy.

The Lammers et al study highlights several ways in which a bayesian analysis can add value to a randomized clinical trial focused on patients with trauma. First, bayesian analysis can quantify the probability of benefit, which may help to direct clinicians more effectively than dichotomies based on $P$ values. Second, the exploration of how results may change with different rational prior to distributions helps to quantify the degree of scientific controversy that remains after the results of the study at hand. Third, bayesian analysis allows for the combination of multiple outcomes into a single probability—for example, in the case of PROPPR, it could calculate the probability of benefit at both 24 hours and 30 days. Fourth, the posterior distribution can be compared with various minimum clinically important differences on either the relative or absolute scale, as Lammers et al did. All of these potential benefits are available regardless of the sample size, which is appealing because the sample size of randomized trials in trauma patients is often limited by logistical, ethical, and funding constraints.

Bayesian reanalysis of randomized clinical trials in trauma and critical care medicine has become increasingly common, but it does have limitations. No analytical approach, bayesian nor frequentist, can fully overcome errors introduced by unfair comparators, unrealistic study populations, ineffective randomization, or missing outcome data. Although often proposed as an antidote to $P$ value–based dichotomization, bayesian analysis does not prevent a similarly reductionist approach that substitutes the probability of benefit for the $P$ value and dichotomizes results around an arbitrary cutoff. The reanalysis process varies by author group and does not always include important elements, such as presenting posterior distributions from a range of different prior distributions, prompting the publication of guidance documents for bayesian reanalyses. Single-trial reanalyses often focus on trials with large differences and small sample sizes, fueling critics who view the entire enterprise as a thinly veiled form of statistical alchemy. However, some bayesian reanalyses, for
example, a reanalysis of the Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Distress Syndrome trial, have had an influence on guideline recommendations and clinical practice.7

Many arguments for the use of bayesian analysis in trauma and critical care medicine have focused on its epistemic advantages, such as a more intuitive formulation of results than that seen in the frequentist paradigm (eg, posterior probability of benefit is X% vs the probability of results as or more extreme than those observed is Y%). However, the future use of bayesian analysis in trauma and critical care medicine is more likely to be driven by pragmatism than epistemology. Platform adaptive trials, such as REMAP-CAP that revolutionized care for patients with COVID-19, rely on bayesian analyses to accommodate multiple interim analyses and stopping rules based on certainty instead of a fixed sample size.8 Platform trials help to improve the efficiency of clinical trials by allowing for multiple scientific hypotheses to be tested within a single larger trial environment focused on an important clinical problem, such as pneumonia or hemorrhagic shock. Platform adaptive trials are much easier to implement with bayesian as opposed to frequentist analytic methods. Indeed, a 2022 study by Tolles et al9 proposed a bayesian platform trial for patients with life-threatening hemorrhage due to trauma. Bayesian analysis is also being used in an ongoing randomized clinical trial in the United Kingdom testing the use of resuscitative endovascular balloon occlusion of the aorta in patients with life-threatening torso hemorrhage, another area of significant controversy in the care of patients with trauma injuries.10

The bayesian reanalysis by Lammers et al3 provides a new way of quantifying the results of the PROPPR trial and highlights the probable mortality benefit of a 1:1:1 as opposed to 1:1:2 transfusion strategy in patients with life-threatening hemorrhage after trauma. Despite the limitations of reanalysis, bayesian methods will prove useful for future studies of patients with life-threatening trauma, especially in preplanned bayesian randomized and platform trials.

