Supplementary Material: Floor and Ceiling Effects in Thrombectomy

A Bayesian Hierarchical Ordinal Meta-analysis of 30 Randomized Trials

Bradley Kolb, MD

Search Strategy, Eligibility Criteria, Study Selection, and Data Handling

Search Strategy

We searched PubMed (MEDLINE via NCBI) from inception to October 19, 2025, with no date limits. The full, reproducible PubMed strategy was:

```
(
"mechanical thrombectomy"[tiab] OR "endovascular thrombectomy"[tiab] OR
"aspiration thrombectomy"[tiab] OR "stent retriever*"[tiab] OR stentriever*[tiab] OR
Solitaire[tiab] OR Trevo[tiab] OR Penumbra[tiab]
)
AND
(
stroke[tiab] OR "ischemic stroke"[tiab] OR "large vessel occlusion"[tiab] OR LVO[tiab] OR
"basilar artery"[tiab] OR "basilar occlusion"[tiab]
)
AND
(
randomized controlled trial[Publication Type] OR random*[tiab] OR trial[tiab]
)
NOT (animals[mh] NOT humans[mh])
AND english[lang]
```

This search returned 327 records.

Eligibility Criteria

- **Design:** Randomized.
- **Population:** Adults with acute ischemic stroke (anterior or posterior circulation).
- **Intervention:** Mechanical thrombectomy (including stent retrievers and/or aspiration).
- **Comparator:** Best medical management (with or without IV thrombolysis).
- **Outcomes:** Functional outcomes (modified Rankin Scale).
- **Exclusions:** Non-randomized studies.

Study Selection and Data Handling

We screened titles/abstracts and then full texts, with disagreements resolved by consensus, as documented in the PRISMA 2020 diagram below.

For each included trial we extracted trial design, population, time window, imaging selection, intervention details (device/approach), comparator, and outcomes (including full-ordinal mRS where available).

For mRS results that were presented as percentages, we obtained mRS counts by assuming the reported percentage of patients achieving the given mRS score was obtained by dividing the number of patients achieving that score in the intention-to-treat population by the total number of patients in the intention-to-treat population across all 6 mRS categories.

PRISMA Diagram

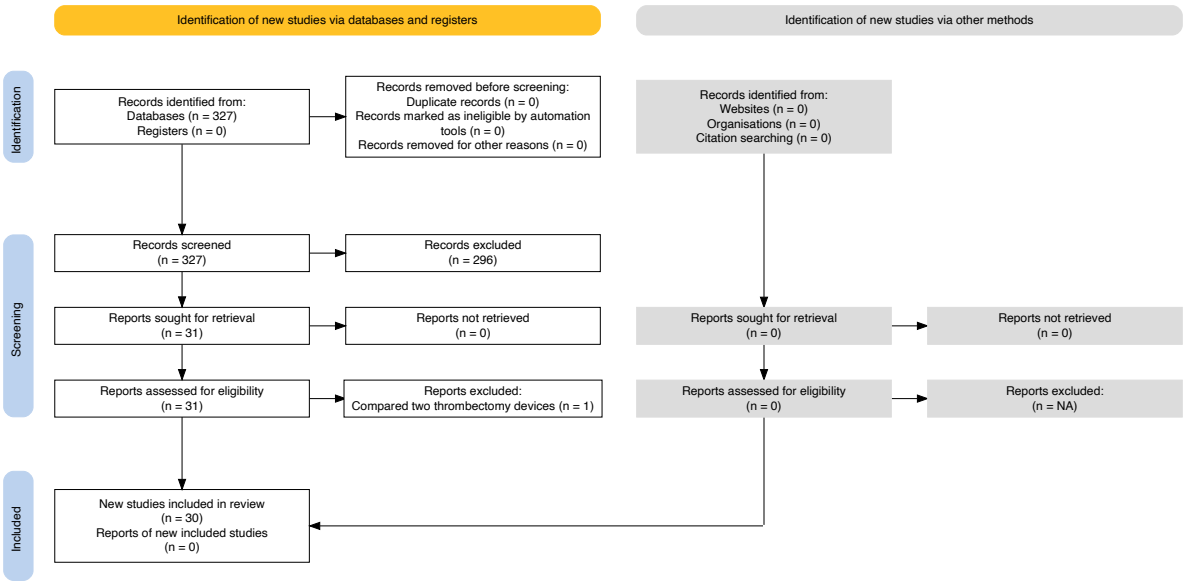

Figure 1: PRISMA 2020 diagram of search strategy and study selection.

Table S1. Trial Characteristics

Table S2. Risk of Bias Assessment

Table S3. Detailed References

All 30 included trials, listed by trial acronym.

1. **SYNTHESIS** — Ciccone A, Valvassori L, Nichelatti M, Sgoifo A, Ponzio M, Sterzi R, et al. Endovascular Treatment for Acute Ischemic Stroke. *N Engl J Med* 2013; 368:904–13.
2. **IMS III** — Broderick JP, Palesch YY, Demchuk AM, Yeatts SD, Khatri P, Hill MD, et al. Endovascular therapy after intravenous t-PA versus t-PA alone for stroke. *N Engl J Med* 2013; 368:893–903.

Table 1: Table S1. Characteristics of the 30 included randomized controlled trials.

Table S1. Trial Characteristics

Trial	Year	N (EVT)	N (Control)	Occlusion	Time Window	Population	Prir
IMS III	2013	415	214	ICA/M1	6 h	Early-window standard LVO	mR
SYNTHESIS	2013	181	181	Mixed	4.5 h	Early-window standard LVO	mR
MR RESCUE	2013	63	54	ICA/M1	8 h	Early-window standard LVO	mR
EXTEND-IA	2015	35	35	ICA/M1	6 h	Early-window standard LVO	mR
SWIFT PRIME	2015	98	93	ICA/M1	6 h	Early-window standard LVO	mR
ESCAPE	2015	163	146	ICA/M1	12 h	Early-window standard LVO	mR
REVASCAT	2015	103	103	ICA/M1	8 h	Early-window standard LVO	mR
MR CLEAN	2015	233	266	ICA/M1	6 h	Early-window standard LVO	mR
THERAPY	2016	50	46	ICA/M1	6 h	Early-window standard LVO	mR
THRACE	2016	200	202	ICA/M1	5 h	Early-window standard LVO	mR
THRILL	2016	2	2	ICA/M1	6 h	Early-window standard LVO	Not
PISTE	2017	33	30	ICA/M1	6 h	Early-window standard LVO	mR
EASI	2017	37	40	Mixed	6 h	Early-window standard LVO	mR
DEFUSE-3	2018	92	90	ICA/M1	6-16 h	Late-window/mismatch	mR
DAWN	2018	108	100	ICA/M1	6-24 h	Late-window/mismatch	mR
RESILIENT	2020	111	112	ICA/M1	8 h	Early-window standard LVO	mR
BEST	2020	66	65	Basilar	8 h	Basilar artery occlusion	mR
BASICS	2021	154	146	Basilar	6 h	Basilar artery occlusion	mR
POSITIVE	2022	12	21	Mixed	12 h	Late-window/mismatch	mR
BAOCHE	2022	111	106	Basilar	6-24 h	Basilar artery occlusion	mR
ATTENTION	2022	225	115	Basilar	12 h	Basilar artery occlusion	mR
RESCUE-Japan LIMIT	2022	100	102	ICA/M1	6 h	Large-core	mR
SELECT2	2023	177	171	ICA/M1	24 h	Large-core	mR
MR CLEAN-LATE	2023	253	247	ICA/M1	6-24 h	Late-window	mR
ANGEL-ASPECT	2023	230	225	ICA/M1	24 h	Large-core	mR
TENSION	2023	124	122	ICA/M1	12 h	Large-core	mR
TESLA	2024	151	146	ICA/M1	6 h	Large-core	mR
LASTE	2024	159	165	ICA/M1	6.5 h	Large-core	mR
DISTAL	2025	271	269	Distal/DMVO	6 h	Medium/distal vessel	mR
ESCAPE-MeVO	2025	255	274	M2/MeVO	12 h	Medium vessel	mR

Table 2: Table S2. Cochrane risk of bias assessment for the 30 included trials.

Table S2. Risk of Bias Assessment[1]

Trial	Random Sequence	Allocation Concealment	Blinding (Performance)	Blinding (Detection)
TESLA	Low risk	Low risk	High risk	Low risk
DISTAL	Low risk	Low risk	High risk	Low risk
ESCAPE-MeVO	Low risk	Low risk	High risk	Low risk
TENSION	Low risk	Low risk	High risk	Low risk
THERAPY	Unclear risk	Low risk	High risk	Low risk
MR CLEAN-LATE	Low risk	Low risk	High risk	Low risk
THRACE	Low risk	Low risk	High risk	Low risk
PISTE	Low risk	Low risk	High risk	Low risk
POSITIVE	Low risk	Low risk	High risk	Low risk
RESILIENT	Low risk	Low risk	High risk	Low risk
DEFUSE-3	Low risk	Low risk	High risk	Low risk
DAWN	Low risk	Low risk	High risk	Low risk
BASICS	Low risk	Low risk	High risk	Low risk
BEST	Low risk	Low risk	High risk	Low risk
BAOCHE	Low risk	Low risk	High risk	Low risk
ATTENTION	Low risk	Low risk	High risk	Low risk
EXTEND-IA	Low risk	Low risk	High risk	Low risk
SWIFT PRIME	Low risk	Low risk	High risk	Low risk
ESCAPE	Low risk	Low risk	High risk	Low risk
REVASCAT	Low risk	Low risk	High risk	Low risk
MR CLEAN	Low risk	Low risk	High risk	Low risk
IMS III	Low risk	Low risk	High risk	Low risk
SYNTHESIS	Low risk	Low risk	Unclear risk	Low risk
MR RESCUE	Low risk	Low risk	High risk	Low risk
RESCUE-Japan LIMIT	Low risk	Low risk	High risk	Low risk
ANGEL-ASPECT	Low risk	Low risk	High risk	Low risk
SELECT2	Low risk	Low risk	High risk	Low risk
THRILL	Low risk	Unclear risk	High risk	Unclear risk
EASI	Low risk	Unclear risk	High risk	High risk
LASTE	Low risk	Low risk	High risk	Low risk

[1]Green = Low risk; Red = High risk; Yellow = Unclear risk.

3. **MR RESCUE** — Kidwell CS, Jahan R, Gornbein J, Alger JR, Nenov V, Ajani Z, et al. A trial of imaging selection and endovascular treatment for ischemic stroke. *N Engl J Med* 2013; 368:914–23.

4. **THRILL** — Bendszus M, Thomalla G, Hacke W, Knauth M, Gerloff C, Bonekamp S, et al. Early termination of THRILL, a prospective study of mechanical thrombectomy in patients with acute ischemic stroke ineligible for i.v. thrombolysis. *Clin Neuroradiol* 2016; 26:499–500.

5. **EASI** — Khoury NN, Darsaut TE, Ghostine J, Deschaintre Y, Daneault N, Durocher A, et al. Endovascular thrombectomy and medical therapy versus medical therapy alone in acute stroke: A randomized care trial. *J Neuroradiol* 2017; 44:198–202.

6. **LASTE** — Costalat V, Jovin TG, Albucher JF, Cognard C, Henon H, Nouri N, et al. Trial of thrombectomy for stroke with a large infarct of unrestricted size. *N Engl J Med* 2024; 390:1677–89.

7. **TESLA** — Writing Committee for the TESLA Investigators, Yoo AJ, Zaidat OO, Sheth SA, Rai AT, Ortega-Gutierrez S, et al. Thrombectomy for stroke with large infarct on noncontrast CT: The TESLA randomized clinical trial. *JAMA* 2024; 332:1355–66.

8. **DISTAL** — Psychogios M, Brehm A, Ribo M, Rizzo F, Strbian D, Räty S, et al. Endovascular treatment for stroke due to occlusion of medium or distal vessels. *N Engl J Med* 2025; published online Feb 5. DOI:10.1056/NEJMoa2408954.

9. **ESCAPE-MeVO** — Goyal M, Ospel JM, Ganesh A, Dowlatshahi D, Volders D, Möhlenbruch MA, et al. Endovascular treatment of stroke due to medium-vessel occlusion. *N Engl J Med* 2025; published online Feb 5. DOI:10.1056/NEJMoa2411668.

10. **TENSION** — Bendszus M, Fiehler J, Subtil F, Bonekamp S, Aamodt AH, Fuentes B, et al. Endovascular thrombectomy for acute ischaemic stroke with established large infarct: multicentre, open-label, randomised trial. *Lancet* 2023; 402:1753–63.

11. **THERAPY** — Mocco J, Zaidat OO, von Kummer R, Yoo AJ, Gupta R, Lopes D, et al. Aspiration Thrombectomy After Intravenous Alteplase Versus Intravenous Alteplase Alone. *Stroke* 2016; 47:2331–8.

12. **MR CLEAN-LATE** — Olthuis SGH, Pirson FAV, Pinckaers FME, Hinsenveld WH, Nieboer D, Ceulemans A, et al. Endovascular treatment versus no endovascular treatment after 6–24 h in patients with ischaemic stroke and collateral flow on CT angiography (MR CLEAN-LATE). *Lancet* 2023; 401:1371–80.

13. **THRACE** — Bracard S, Ducrocq X, Mas JL, Soudant M, Oppenheim C, Moulin T, et al. Mechanical thrombectomy after intravenous alteplase versus alteplase alone after stroke (THRACE): a randomised controlled trial. *Lancet Neurol* 2016; 15:1138–47.

14. **PISTE** — Muir KW, Ford GA, Messow CM, Ford I, Murray A, Clifton A, et al. Endovascular therapy for acute ischaemic stroke: the Pragmatic Ischaemic Stroke Thrombectomy Evaluation (PISTE) randomised, controlled trial. *J Neurol Neurosurg Psychiatry* 2017; 88:38–44.

15. **POSITIVE** — Mocco J, Siddiqui AH, Fiorella D, Alexander MJ, Arthur AS, Baxter BW, et al. POSITIVE: Perfusion imaging selection of ischemic stroke patients for endovascular therapy. *J Neurointerv Surg* 2022; 14:126–32.

16. **RESILIENT** — Martins SO, Mont'Alverne F, Rebello LC, Abud DG, Silva GS, Lima FO, et al. Thrombectomy for Stroke in the Public Health Care System of Brazil. *N Engl J Med* 2020; 382:2316–26.

17. **DEFUSE-3** — Albers GW, Marks MP, Kemp S, Christensen S, Tsai JP, Ortega-Gutierrez S, et al. Thrombectomy for Stroke at 6 to 16 Hours with Selection by Perfusion Imaging. *N Engl J Med* 2018; 378:708–18.

18. **DAWN** — Nogueira RG, Jadhav AP, Haussen DC, Bonafe A, Budzik RF, Bhuva P, et al. Thrombectomy 6 to 24 Hours after Stroke with a Mismatch between Deficit and Infarct. *N Engl J Med* 2018; 378:11–21.

19. **BASICS** — Langezaal LCM, van der Hoeven EJRJ, Mont'Alverne FJA, de Carvalho JJF, Lima FO, Dippel DWJ, et al. Endovascular Therapy for Stroke Due to Basilar-Artery Occlusion. *N Engl J Med* 2021; 384:1910–20.

20. **BEST** — Liu X, Dai Q, Ye R, Zi W, Liu Y, Wang H, et al. Endovascular treatment versus standard medical treatment for vertebrobasilar artery occlusion (BEST): an open-label, randomised controlled trial. *Lancet Neurol* 2020; 19:115–22.

21. **ATTENTION** — Tao C, Nogueira RG, Zhu Y, Sun J, Han H, Yuan G, et al. Trial of Endovascular Treatment of Acute Basilar-Artery Occlusion. *N Engl J Med* 2022; 387:1361–72.

22. **BAOCHE** — Jovin TG, Li C, Wu L, Wu C, Chen J, Jiang C, et al. Trial of Thrombectomy 6 to 24 Hours after Stroke Due to Basilar-Artery Occlusion. *N Engl J Med* 2022; 387:1373–84.

23. **EXTEND-IA** — Campbell BCV, Mitchell PJ, Kleinig TJ, Dewey HM, Churilov L, Yassi N, et al. Endovascular therapy for ischemic stroke with perfusion-imaging selection. *N Engl J Med* 2015; 372:1009–18.

24. **SWIFT PRIME** — Saver JL, Goyal M, Bonafe A, Diener H-C, Levy EI, Pereira VM, et al. Stent-retriever thrombectomy after intravenous t-PA vs. t-PA alone in stroke. *N Engl J Med* 2015; 372:2285–95.

25. **ESCAPE** — Goyal M, Demchuk AM, Menon BK, Eesa M, Rempel JL, Thornton J, et al. Randomized assessment of rapid endovascular treatment of ischemic stroke. *N Engl J Med* 2015; 372:1019–30.

26. **REVASCAT** — Jovin TG, Chamorro A, Cobo E, de Miquel MA, Molina CA, Rovira A, et al. Thrombectomy within 8 hours after symptom onset in ischemic stroke. *N Engl J Med* 2015; 372:2296–306.

27. **MR CLEAN** — Berkhemer OA, Fransen PSS, Beumer D, van den Berg LA, Lingsma HF, Yoo AJ, et al. A randomized trial of intraarterial treatment for acute ischemic stroke. *N Engl J Med* 2015; 372:11–20.

28. **RESCUE-Japan LIMIT** — Yoshimura S, Sakai N, Yamagami H, Uchida K, Beppu M, Toyoda K, et al. Endovascular Therapy for Acute Stroke with a Large Ischemic Region. *N Engl J Med* 2022; 386:1303–13.

29. **ANGEL-ASPECT** — Huo X, Ma G, Tong X, Zhang X, Pan Y, Nguyen TN, et al. Trial of Endovascular Therapy for Acute Ischemic Stroke with Large Infarct. *N Engl J Med* 2023; 388:1272–83.

30. **SELECT2** — Sarraj A, Hassan AE, Abraham MG, Ortega-Gutierrez S, Kasner SE, Hussain MS, et al. Trial of Endovascular Thrombectomy for Large Ischemic Strokes. *N Engl J Med* 2023; 388:1259–71.

Statistical Details

Main Model Specification

The main model was a Bayesian hierarchical proportional-odds cumulative ordinal model fit with `brms` (Stan backend via `cmdstanr`). The model formula was:

```
mrs_better | weights(count) ~ treatment + (1 + treatment | trial)
Family: cumulative (logit link)
Priors: Normal(0, 1) for fixed effects, standard deviations, and thresholds
Chains: 4  |  Iterations: 2000 (1000 warmup)  |  Total post-warmup draws: 4000
```

Main model summary output:

```
Family: cumulative
Links: mu = logit
Formula: ordinal_value ~ treatment + (1 + treatment | trial)
Data: data_long (Number of observations: 8100)
Draws: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;
       total post-warmup draws = 4000
```

```
Multilevel Hyperparameters:
~trial (Number of levels: 30)

                                    Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_
sd(Intercept)                           0.75      0.11     0.57     1.00 1.00     1003     1
sd(treatmentthrombectomy)               0.35      0.08     0.22     0.51 1.00     1472     2
cor(Intercept,treatmentthrombectomy)   -0.49      0.18    -0.79    -0.09 1.00     2250     2

Regression Coefficients:
              Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
Intercept[1]     -1.08      0.15    -1.37    -0.80 1.01      490     1069
Intercept[2]     -0.52      0.14    -0.81    -0.24 1.01      485     1124
Intercept[3]      0.25      0.14    -0.03     0.53 1.01      488      949
Intercept[4]      0.96      0.14     0.67     1.23 1.01      488      953
Intercept[5]      1.69      0.14     1.41     1.98 1.01      496     1114
Intercept[6]      2.91      0.15     2.62     3.21 1.01      520     1028
treatmentthrombectomy  0.46  0.08  0.30  0.62 1.00  1467  2271
```

All Rhat values 1.01, indicating convergence. Bulk and tail effective sample sizes were adequate (all >400 for key parameters).

Model Diagnostics

The following diagnostic figures are generated by running `run.R` and are saved to `artifacts/` (not tracked in git due to file size). After running the analysis, they can be found at the paths indicated.

Trace Plots (`Figures/ordinal_trace_plots.svg`)

Markov chain trace plots for the six threshold parameters, the treatment effect, and the three variance-covariance hyperparameters.

If this figure is missing, run `master_supporting_docs/supporting_code/run.R` to generate the diagnostic SVGs.

R-hat and Effective Sample Size (`Figures/ordinal_convergence_values.svg`)

If this figure is missing, run `master_supporting_docs/supporting_code/run.R` to generate the diagnostic SVGs.

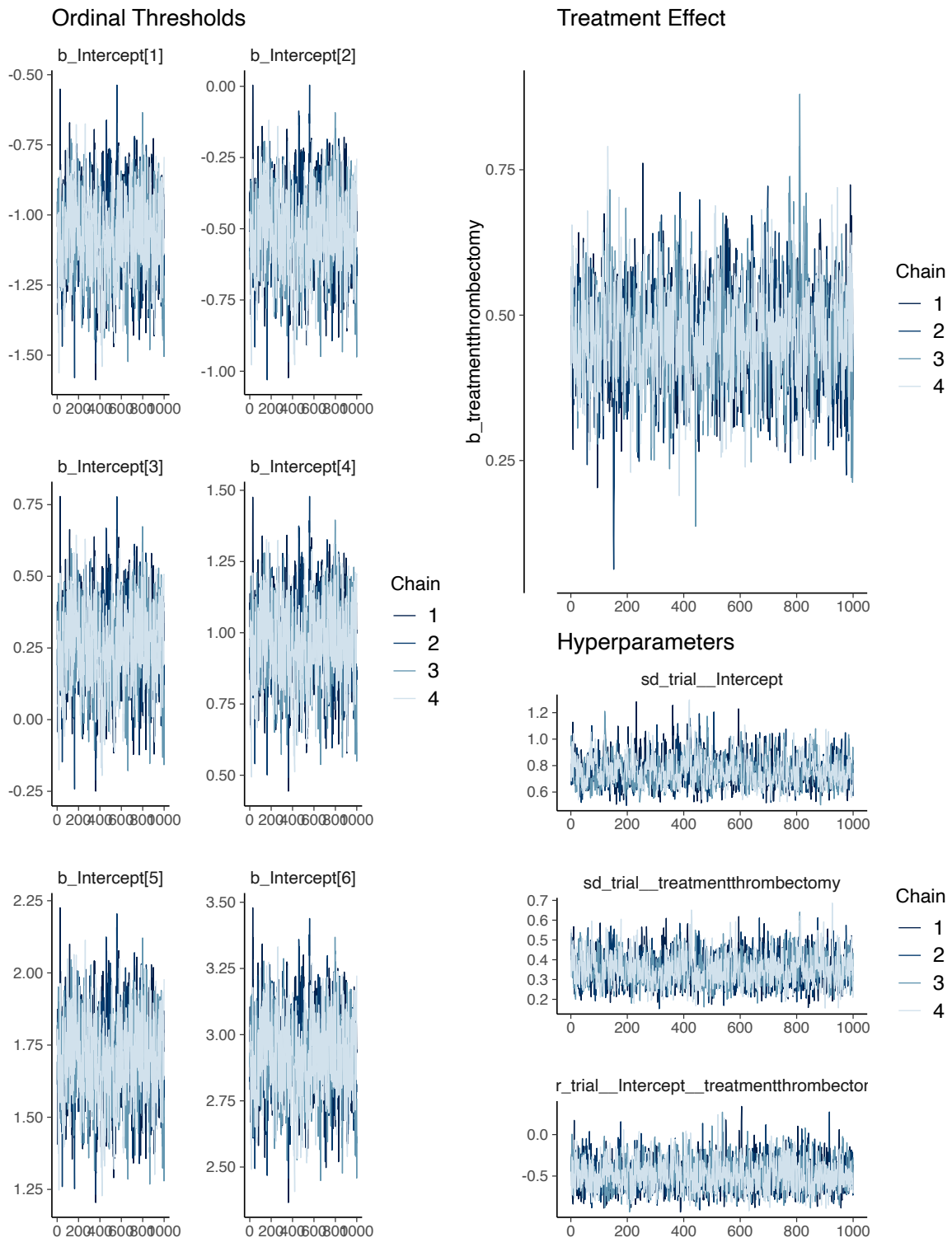

Figure 2: Trace plots for main model parameters.

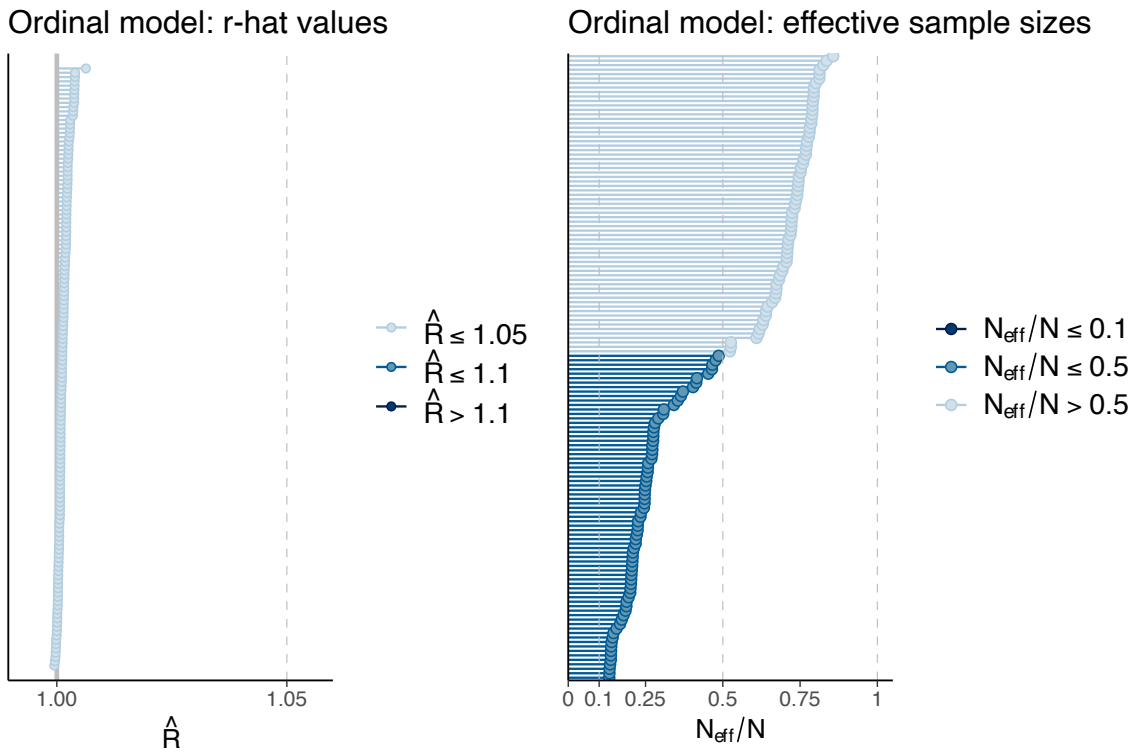

Figure 3: R-hat values and effective sample sizes for main model.

Posterior Predictive Check (`Figures/ordinal_posterior_predictive_check.svg`)

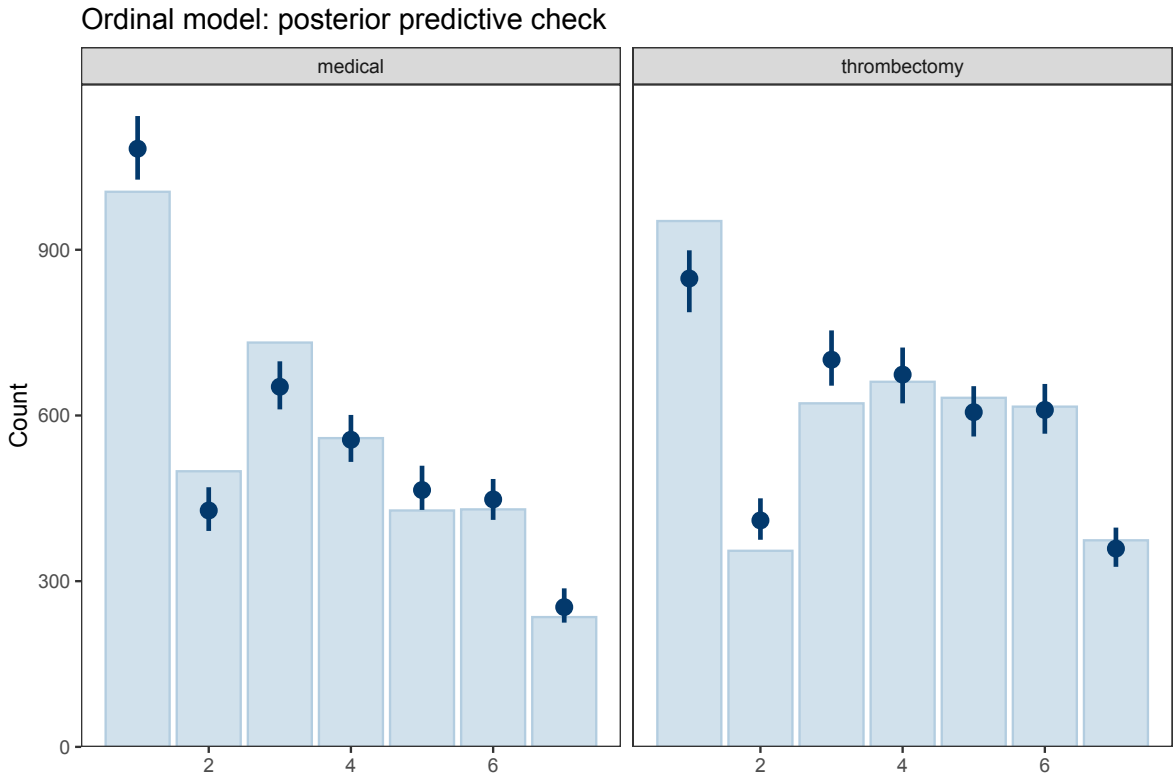

Figure 4: Posterior predictive check for the main model, grouped by treatment arm.

If this figure is missing, run `master_supporting_docs/supporting_code/run.R` *to generate the diagnostic SVGs.*

Prior Sensitivity (`Figures/ordinal_power_scaling_sensitivity.svg`)

Prior power-scaling sensitivity analysis for key model parameters. Sensitivity was low across all parameters.

If this figure is missing, run `master_supporting_docs/supporting_code/run.R` *to generate the diagnostic SVGs.*

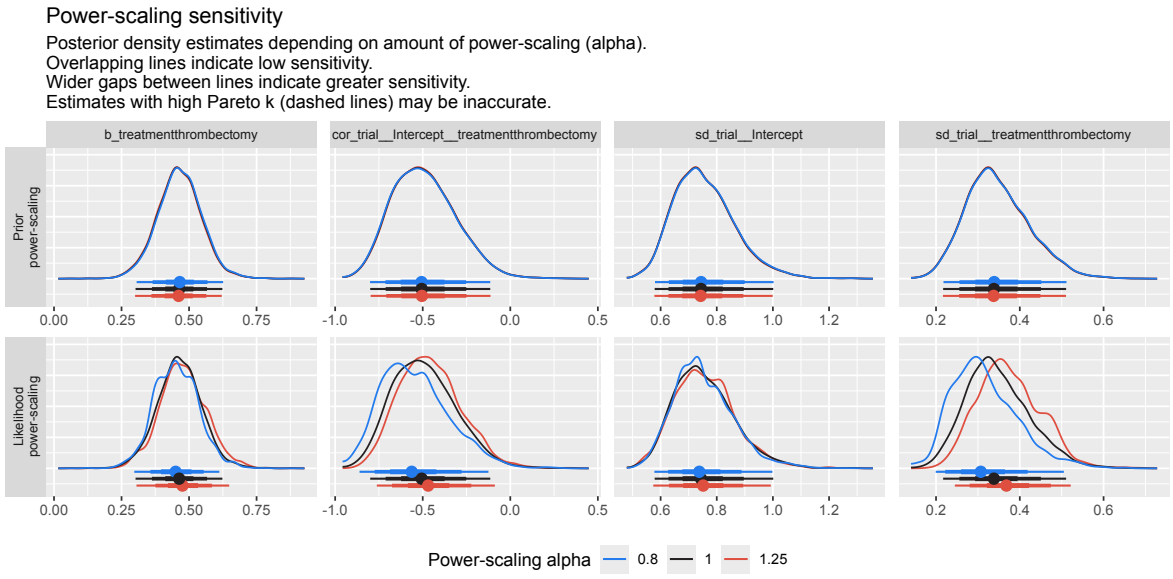

Figure 5: Prior sensitivity (power-scaling) analysis for the main model.

Alternative Models

Three additional prespecified models were fit to assess robustness of the main findings.

Alternative Model 1: Ordinal (PO + Unequal Variances)

```
Family: cumulative
Links: mu = logit; disc = log
Formula: mrs_better | weights(count) ~ treatment + (1 + treatment | trial)
         disc ~ 0 + treatment
Data: data_long (Number of observations: 420)
Draws: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;
       total post-warmup draws = 4000

Multilevel Hyperparameters (~trial, 30 levels):
  sd(Intercept)                           0.80  (SE 0.11; 95% CI 0.61-1.04)
  sd(treatmentthrombectomy)               0.37  (SE 0.08; 95% CI 0.23-0.55)
  cor(Intercept,treatmentthrombectomy)   -0.46  (SE 0.19; 95% CI -0.76 to -
0.06)

Key Regression Coefficients:
  treatmentthrombectomy       0.48  (SE 0.08; 95% CI 0.31-0.64)
  disc_treatmentthrombectomy -0.14  (SE 0.02; 95% CI -0.18 to -0.09)
```

Alternative Model 2: Ordinal (Adjacent-Category)

```
Family: acat (adjacent-category logit)
Formula: mrs_better | weights(count) ~ treatment + (1 + treatment | trial)
Data: data_long (Number of observations: 403)
Draws: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;
       total post-warmup draws = 4000

Multilevel Hyperparameters (~trial, 30 levels):
  sd(Intercept)                            0.25  (SE 0.04; 95% CI 0.19-0.33)
  sd(treatmentthrombectomy)                0.11  (SE 0.02; 95% CI 0.07-0.17)
  cor(Intercept,treatmentthrombectomy)    -0.62  (SE 0.16; 95% CI -0.87 to -
0.28)

Key Regression Coefficients:
  treatmentthrombectomy   0.15  (SE 0.03; 95% CI 0.10-0.20)
```

Alternative Model 3: Binary (mRS 0–2 vs 3–6)

```
Family: binomial (logit link)
Formula: good_n | trials(total_n) ~ treatment + (1 + treatment | trial)
Data: data_bin (Number of observations: 60)
Draws: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;
       total post-warmup draws = 4000

Multilevel Hyperparameters (~trial, 30 levels):
  sd(Intercept)                            0.98  (SE 0.14; 95% CI 0.74-1.29)
  sd(treatmentthrombectomy)                0.54  (SE 0.10; 95% CI 0.37-0.78)
  cor(Intercept,treatmentthrombectomy)    -0.65  (SE 0.14; 95% CI -0.88 to -
0.32)

Key Regression Coefficients:
  Intercept               -1.16  (SE 0.18; 95% CI -1.52 to -0.81)
  treatmentthrombectomy    0.67  (SE 0.12; 95% CI 0.44-0.90)
```

All three alternative models yield a consistently negative intercept–slope correlation, confirming robustness of the main finding.

Figure S1. Robustness of ρ to Model Specification

Posterior medians and 95% credible intervals for ρ under the primary proportional-odds ordinal model and three alternative prespecified models: an unequal-variance proportional-odds model, an adjacent-category ordinal model, and a binary model (mRS 0–2 vs 3–6). Estimates remain negative across all specifications.

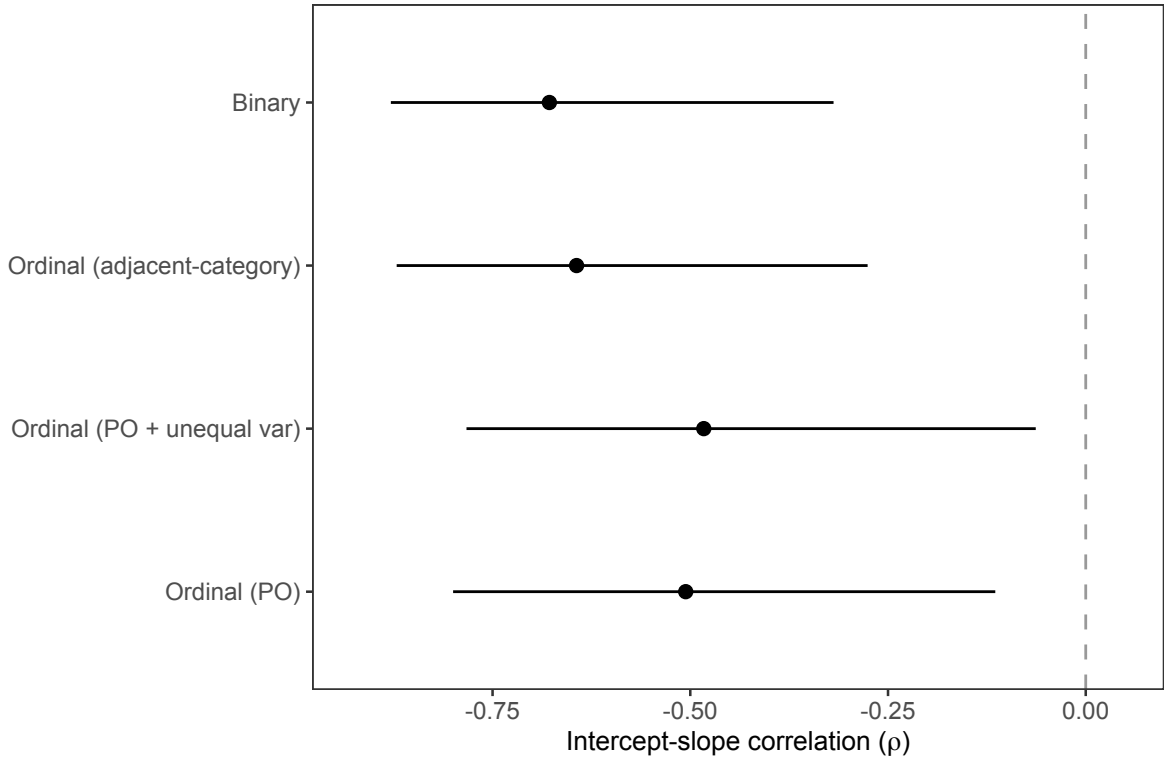

Figure 6: Figure S1. Robustness of the intercept–slope correlation to model specification.

Figure S2. Absolute Benefit Across Model Specifications

For each model, points show each trial's posterior median control-group probability of functional independence (x-axis) and posterior median absolute benefit in functional independence due to thrombectomy (y-axis). Functional independence is defined as mRS 0–2. The dashed line indicates no absolute benefit; the smooth curve is a descriptive fit with 95% uncertainty band.

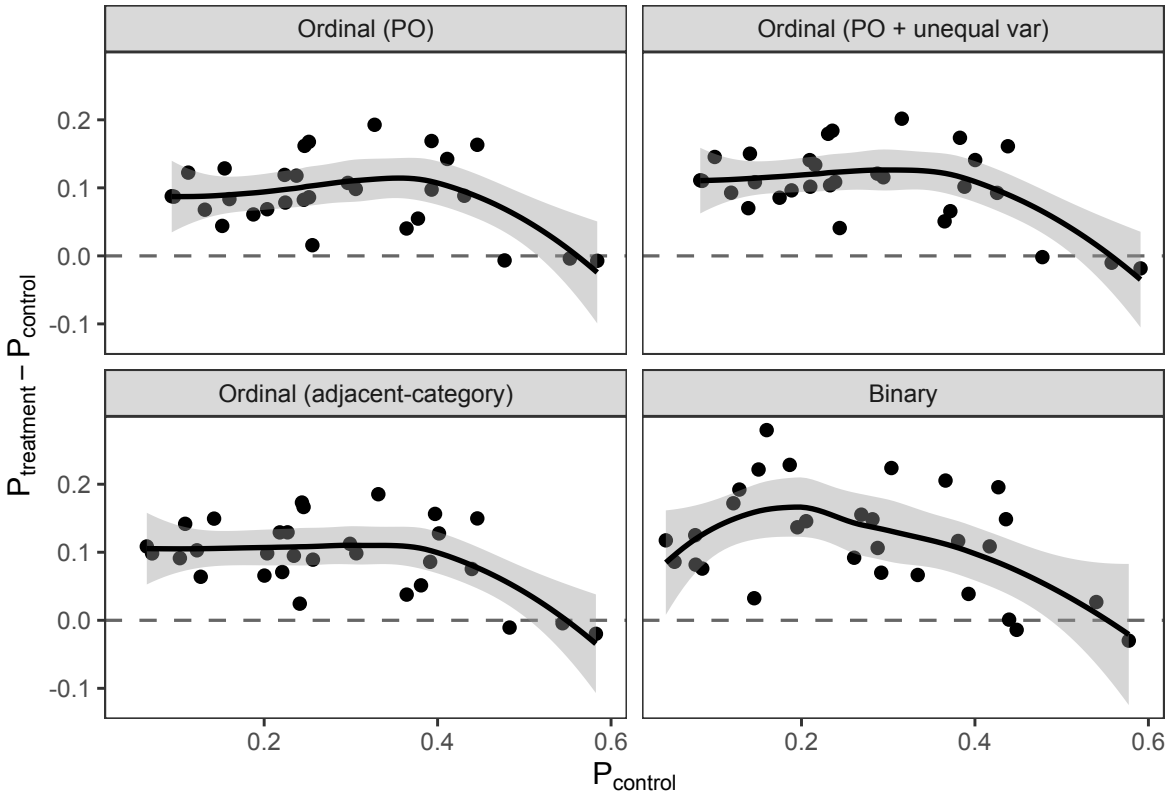

Figure 7: Figure S2. Baseline prognosis and absolute benefit in functional independence.