MetaSuite: Empowering Network Meta-Analysis in Clinical Research Through Interactive Visualizations and User-Friendly Evidence Synthesis Tools

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BACKGROUND & MOTIVATION

The Evidence Synthesis Challenge

- Evidence synthesis is central to clinical research and regulatory decision-making
- **Traditional workflows are fragmented:**
  - Risk-of-bias assessment in separate tools
  - Statistical analysis in different platforms
  - Visualization disconnected from computation
- **Consequences of fragmentation:**
  - Reduced reproducibility
  - Complex validation workflows
  - Limited transparency for regulatory review
  - Manual transitions between platforms introduce errors

MetaSuite: Unified Evidence Synthesis

- **Why MetaSuite?**
  - Integrates full lifecycle of evidence synthesis in ONE platform
  - Three core modules: Risk of Bias → Pairwise Meta-Analysis → Network Meta-Analysis
  - Built on established R packages (**metafor, netmeta, rankinma**)
  - Open-source and freely available
- **Design Philosophy:**
- **Modularity:** Independent, reusable components
- **Explicit Execution Control:** All computations triggered by user action
- **Separation of Concerns**: Validate → Prepare → Estimate → Diagnose → Visualize
- **Traceability:** Intermediate results accessible throughout
- **Presentation Safety:** Customization is downstream-only, never affects statistics

SHINY USER INTERFACE

Interface Components:

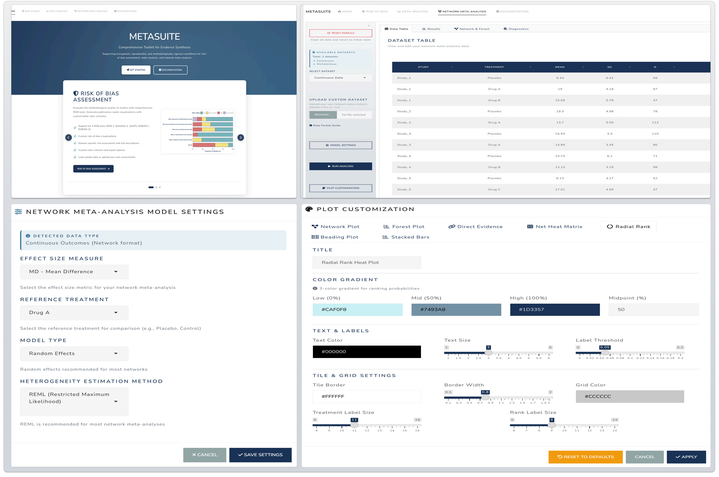
- Global navigation for module selection
- Context-sensitive sidebar for parameter configuration
- Task-oriented tabs: Data → Analysis → Visualizations
- Real-time validation with guided workflows

Key Features:

- Automatic data type detection (continuous, dichotomous, correlation, network)
- No R programming knowledge required
- Validation gates prevent invalid analyses
- Export: PNG (300 DPI), JPG, Excel, CSV

Customization:

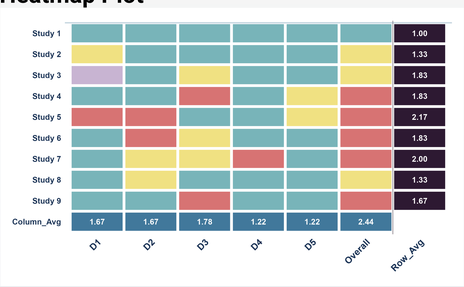
- Plot customization panel activates after statistical estimation
- Controls colors, fonts, plot types independently
- Visual modifications never re-run statistical models
- Publication-ready outputs with journal-specific formatting



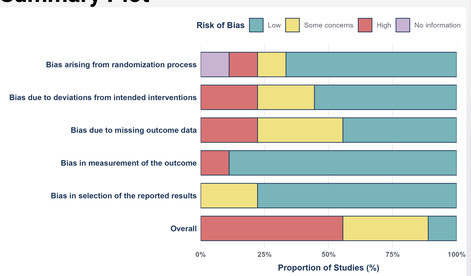
RISK OF BIAS (ROB) ASSESSMENT

- **Summary (Bar) Plot:** Displays aggregate proportion of studies classified as Low/Some Concerns/High risk across all bias domains
- **Traffic Light Plot:** Color-coded study-by-domain matrix showing individual risk assessments with intuitive visual encoding
- **Heatmap Plot:** Numeric risk scores enabling quantitative pattern detection and clustering analysis across studies and domains

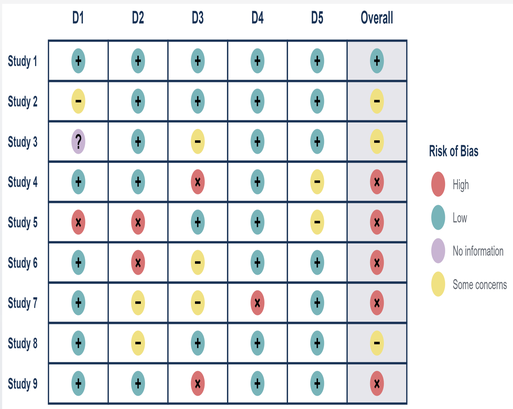
Heatmap Plot



Summary Plot



Traffic Light Plot



D1: Bias arising from randomization process

D2: Bias due to deviations from intended interventions

D3: Bias due to missing outcome data

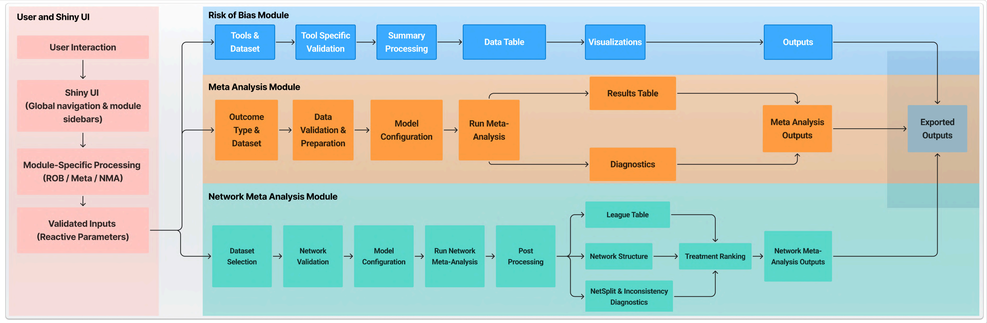
D4: Bias in measurement of the outcome

D5: Bias in selection of the reported results

SYSTEM ARCHITECTURE

Design Principles:

- Three independent Shiny modules: Risk of Bias, Meta-Analysis, Network Meta-Analysis
- Modular design enables independent testing, code review, and regulatory audit
- Bootstrap 5 via bslib for responsive, accessible interface
- Independent, reusable components with standardized pipelines
- Defensive checks ensure accurate data type detection and prevent silent re-computation of statistical models
- Cached intermediate results and audit trails support regulatory review
- Downstream-only plot customization prevents visual modifications from altering statistical result



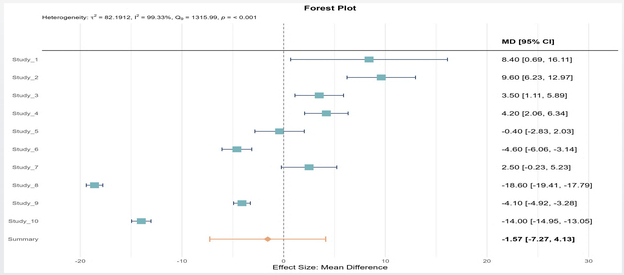
Try MetaSuite

Scan the QR code to access the live application and documentation.

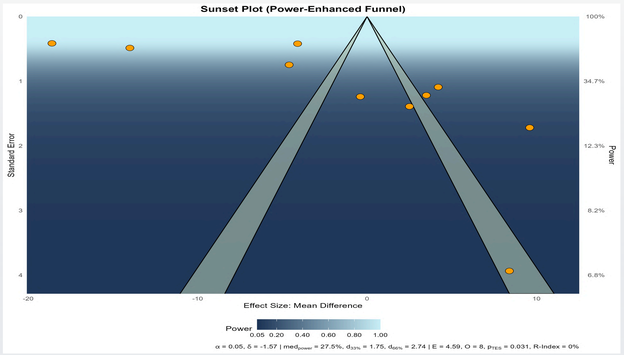
META ANALYSIS

- **Forest Plot:** Individual study effect estimates with confidence intervals and pooled summary effect size
- **Funnel Plot & Sunset Plot**: Asymmetry detection for publication bias assessment with contour-enhanced regions of statistical significance
- **Leave-One-Out Plot:** Sequential study removal analysis to identify influential studies affecting pooled estimates
- **Heterogeneity Metrics:** I^2 (percentage of variation due to heterogeneity), τ^2 (between-study variance), and Q-statistic with p-value

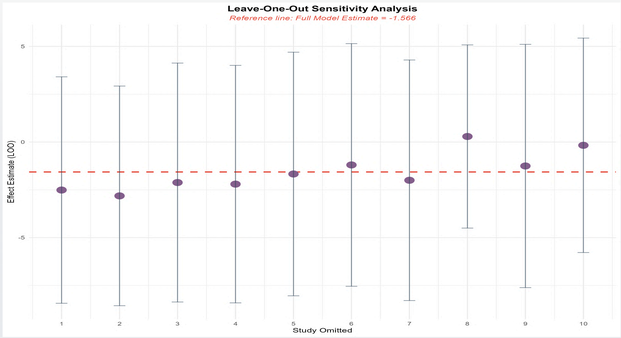
Forest Plot



Sunset Plot



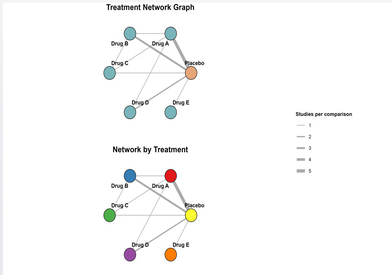
Leave One Out Plot



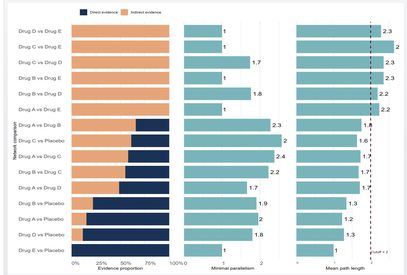
NETWORK META ANALYSIS

- **Network Graph:** Visual representation of treatment nodes connected by study-weighted edges showing evidence density and connectivity
- **Direct vs Indirect Evidence Plot:** Side-by-side comparison assessing coherence between direct trial evidence and network-derived indirect estimates
- **Radial Rank Plot:** Circular visualization displaying agreement between pairwise estimates and overall treatment hierarchy rankings
- **SUCRA Beading Plot:** Surface Under the Cumulative Ranking curve with uncertainty intervals showing treatment ranking probabilities

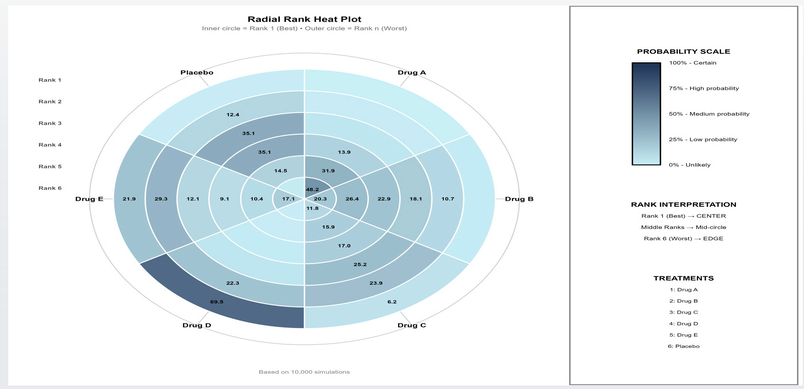
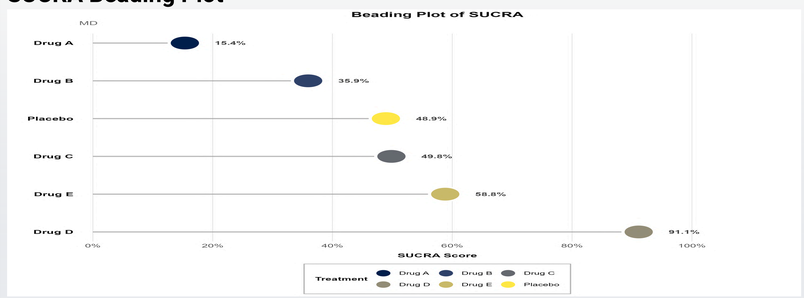
Network Plot



Evidence Plot



Rank Radial Plot



SUCRA Beading Plot