Advanced Review Methodologies in Medical Sciences: Systematic Evidence Synthesis, Bibliometrics, and Meta-Analytic Frameworks

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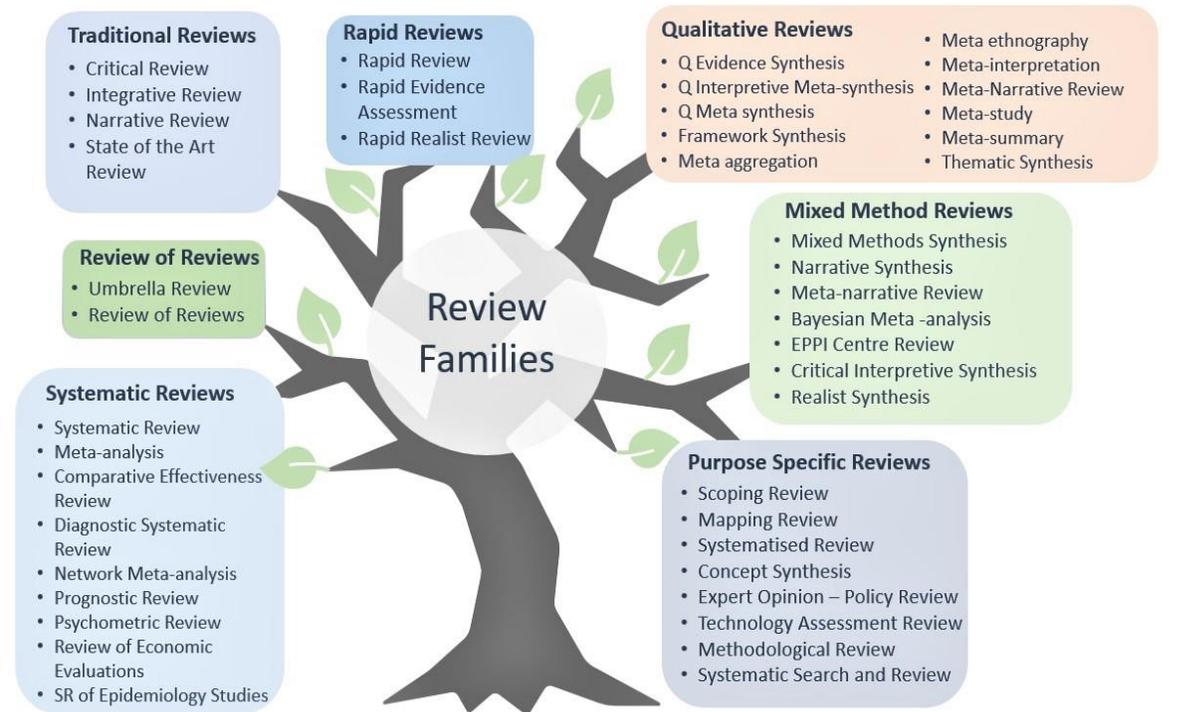
Why reviews are critical ?

- Reviews aggregate **heterogeneous evidence** across biomedical disciplines.

- Systematic reviews and meta-analyses occupy the **apex of the evidence hierarchy**.

- Reviews drive:
- **Clinical guideline formulation** (e.g., NICE, WHO).
- **Policy-making in public health**.
- **Molecular biomarker validation** (e.g., IL-6, TNF-α, amyloid-beta).
- Evidence pyramid represented mathematically as:

$$\text{Evidence Strength} \propto \log\left(\frac{\text{Reproducibility} \times \text{Sample Size}}{\text{Bias}}\right)$$

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Typology of Reviews

- **Narrative Reviews:** Exploratory, interpretive, high risk of bias.

- **Systematic Reviews:** Pre-specified protocols, replicable, PRISMA standards.

- **Meta-Analyses:** Quantitative synthesis, effect size pooling.

- **Umbrella Reviews:** Synthesis of SRs and MAs.

- **Scoping Reviews:** Mapping evidence, identifying research gaps.

- **Rapid Reviews:** Policy-driven, abridged methodologies.

- **Bibliometric Reviews:** Citation and co-authorship networks.

- **Living Reviews:** Continuously updated with new evidence.

Traditional Reviews
- Critical Review
- Integrative Review
- Narrative Review
- State of the Art Review

Rapid Reviews
- Rapid Review
- Rapid Evidence Assessment
- Rapid Realist Review

Qualitative Reviews
- Q Evidence Synthesis
- Q Interpretive Meta-synthesis
- Q Meta synthesis
- Framework Synthesis
- Meta aggregation
- Meta ethnography
- Meta-interpretation
- Meta-Narrative Review
- Meta-study
- Meta-summary
- Thematic Synthesis

Review of Reviews
- Umbrella Review
- Review of Reviews

Review Families

Mixed Method Reviews
- Mixed Methods Synthesis
- Narrative Synthesis
- Meta-narrative Review
- Bayesian Meta -analysis
- EPPI Centre Review
- Critical Interpretive Synthesis
- Realist Synthesis

Systematic Reviews
- Systematic Review
- Meta-analysis
- Comparative Effectiveness Review
- Diagnostic Systematic Review
- Network Meta-analysis
- Prognostic Review
- Psychometric Review
- Review of Economic Evaluations
- SR of Epidemiology Studies

Purpose Specific Reviews
- Scoping Review
- Mapping Review
- Systematised Review
- Concept Synthesis
- Expert Opinion – Policy Review
- Technology Assessment Review
- Methodological Review
- Systematic Search and Review

Sutton, A., Clowes, M., Preston, L., & Booth, A. (2019). Meeting the review family: exploring review types and associated information retrieval requirements. Health Information & Libraries Journal, 36(3), 202-222.
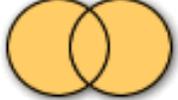
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Review Registration

- **PROSPERO:** Gold standard for systematic review registration in health sciences.

- **Open Science Framework:** Supports multidisciplinary protocols and open data.

- **Cochrane Library Protocols:** Highly standardised, peer-reviewed.

- **Campbell Collaboration**: Evidence in health, education, social policy.

Registration prevents:

- Duplication.
- Selective outcome reporting.
- Post hoc protocol modifications.

NIHR | National Institute for Health and Care Research

PROSPERO
International prospective register of systematic reviews

Open Science Framework

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Search Strategies and Databases

Boolean Operator	Examples	Retrieves
AND	children and television rodgers AND hammerstein children AND poverty	Retrieves records containing both terms
OR	television or television viewing sixties OR 60s OR 1960s labor OR labour	Retrieves records containing either one or both terms
NOT	television not movies caribbean NOT cuba s1 NOT s2	Excludes records containing the second term

- Core databases: **PubMed/MEDLINE, Embase, Cochrane CENTRAL, Web of Science, Scopus**.

- Specialist databases: **PsycINFO, CINAHL, LILACS, ClinicalTrials.gov, medRxiv/bioRxiv**.

- Grey literature sources: dissertations, regulatory reports, WHO ICTRP.

- Boolean operators:

  ("Alzheimer's disease" AND ("exercise" OR "physical activity"))

- Truncation and wildcards increase retrieval sensitivity.

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Controlled Vocabulary (MeSH, Emtree)

- **MeSH (Medical Subject Headings)**: structured medical ontology.
- Hierarchical indexing: *disease → organ → molecular pathway*.
- Reduces semantic heterogeneity.
- Example: "Myocardial Infarction" vs. "Heart Attack".
- Enhances precision in systematic searches.

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Bibliometric Reviews

- Evaluates **research trends, impact, and collaborations**.

- Key indicators:
    - **H-index** (author productivity/impact).
    - **Impact Factor, Eigenfactor** (journal-level).
    - **Altmetrics** (social/scientific media impact).

- Network visualisation:
    - **Co-authorship maps**.
    - **Keyword co-occurrence**.
    - **Citation burst detection**.

- Tools: **VOSviewer, CiteSpace, Bibliometrix (R package)**.

Fig.11 Co-occurrence network with thematic map (Author`s Keywords).
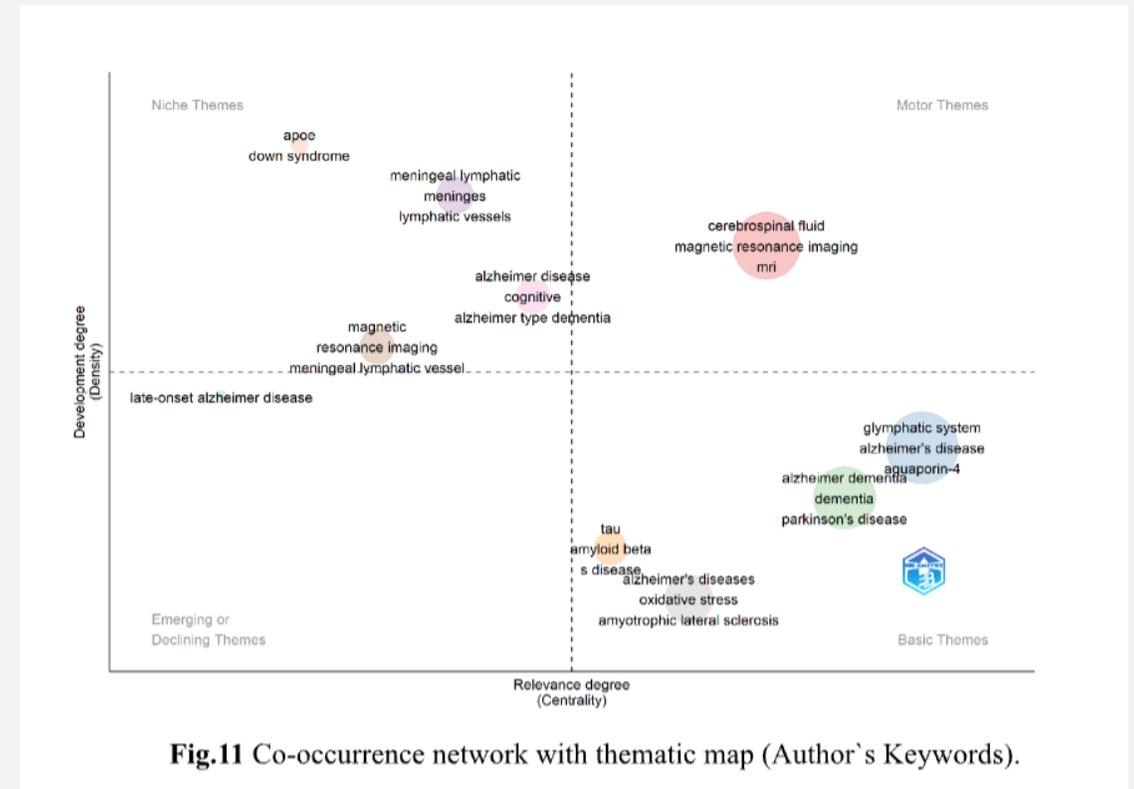
Screening and Eligibility

- **Duplicate removal** (EndNote, Zotero, Rayyan).

- **Two-stage process:** title/abstract → full text.

- **Cohen's Kappa** for inter-rater reliability:

$$\kappa = \frac{P_o - P_e}{1 - P_e}, \quad \text{where } P_o = \text{observed agreement}, \ P_e = \text{expected by chance}$$

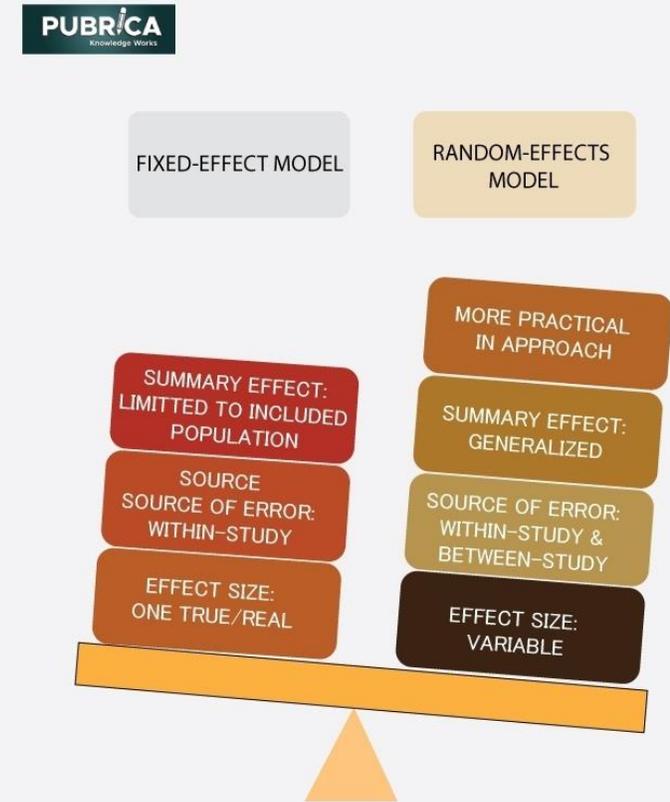- Discrepancies resolved by consensus or third reviewer.

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Statistical Models for Synthesis

- **Fixed-effect model** (inverse variance weighting).

- **Random-effects model** (DerSimonian–Laird, REML, Hartung-Knapp).

- General formula:

$$\hat{\theta} = \frac{\sum_{i=1}^{k} w_i \cdot \theta_i}{\sum_{i=1}^{k} w_i}, \quad w_i = \frac{1}{\sigma_i^2 + \tau^2}$$

- Heterogeneity assessment:

$$Q = \sum_{i=1}^{k} w_i(\theta_i - \hat{\theta})^2, \quad I^2 = \frac{Q - (k-1)}{Q} \times 100\%$$

PUBRICA
Knowledge Works

FIXED-EFFECT MODEL

RANDOM-EFFECTS MODEL

MORE PRACTICAL IN APPROACH

SUMMARY EFFECT: LIMITTED TO INCLUDED POPULATION

SUMMARY EFFECT: GENERALIZED

SOURCE SOURCE OF ERROR: WITHIN–STUDY

SOURCE OF ERROR: WITHIN–STUDY & BETWEEN–STUDY

EFFECT SIZE: ONE TRUE/REAL
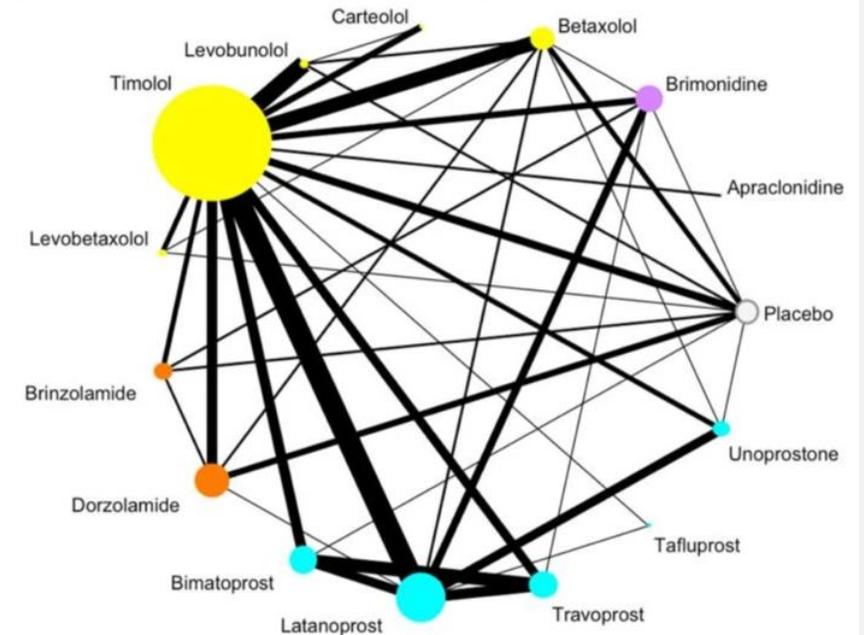
EFFECT SIZE: VARIABLE

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Meta-Analysis Extensions

- **Network Meta-Analysis (NMA):** indirect comparisons, graph-theoretic representation.

- **Meta-Regression:** continuous or categorical moderators.

- **Individual Participant Data Meta-Analysis (IPD-MA):** raw data pooling.

- **Bayesian Models:**

$$\theta|D \sim \mathcal{N}(\mu, \tau^2), \quad p(\theta|D) \propto p(D|\theta) \cdot p(\theta)$$

Fig. 1: Network diagram from Li et al. (2016) [10] comparing medications for POAG.

Size of nodes represents the number of patients, line thickness represents number of trials.

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Diagnostic Accuracy Reviews

- Sensitivity & Specificity:

$$Se = \frac{TP}{TP + FN}, \quad Sp = \frac{TN}{TN + FP}$$

	Gold Standard Test		
		Positive	Negative
Diagnostic Test being evaluated	Positive	TP	FP
	Negative	FN	TN

Sensitivity: TP/(TP+FN) Positive Predictive Value: TP/(TP+FP)
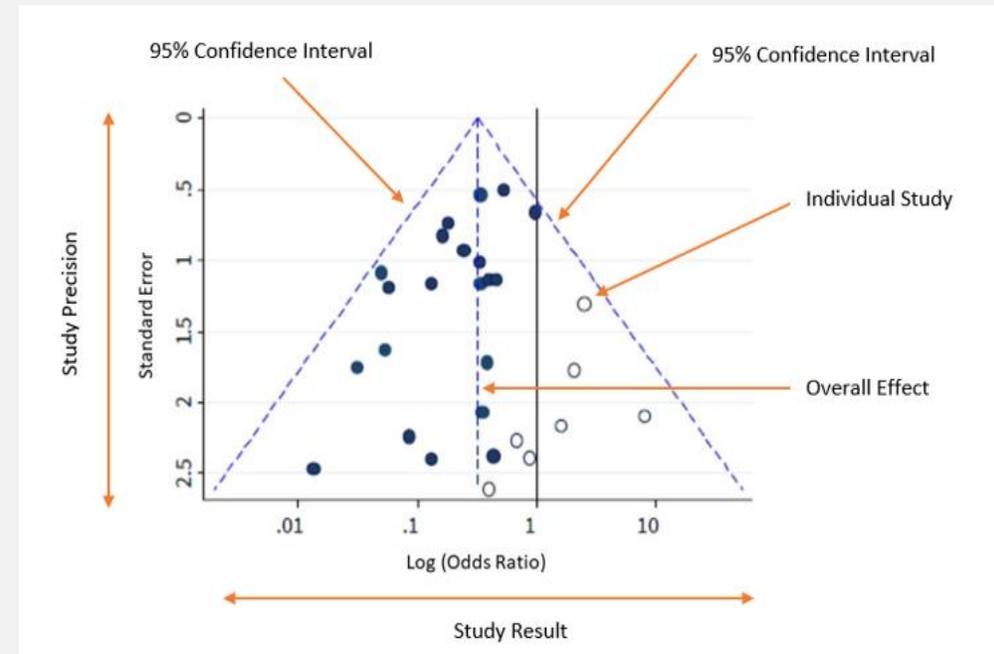Specificity: TN/(TN+FP) Negative Predictive Value: TN/(TN+FN)

- Likelihood ratios:

$$LR^{+} = \frac{Se}{1 - Sp}, \quad LR^{-} = \frac{1 - Se}{Sp}$$

- Diagnostic Odds Ratio (DOR):

$$DOR = \frac{TP \cdot TN}{FP \cdot FN}$$

- Hierarchical models (HSROC, bivariate models).

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Risk of Bias and Quality Assessment

- Tools:
  - **Cochrane RoB2** (RCTs).
  - **ROBINS-I** (non-randomised studies).
  - **QUADAS-2** (diagnostic accuracy).

- Publication bias:
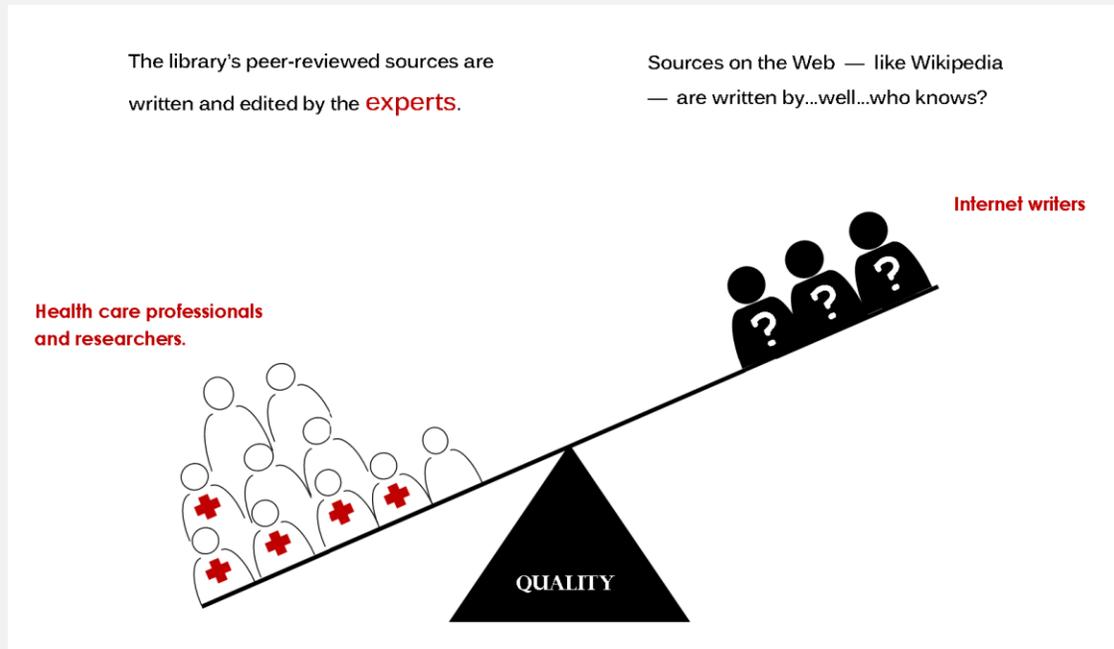 - Funnel plot asymmetry.
  - Egger's regression test:

$$Y_i = \beta_0 + \beta_1 \cdot SE(\theta_i) + \epsilon_i$$

Figure 5. Risk of bias summary: Review authors' judgements about each risk of bias item for each included trial.

Clinical Relevance

The library's peer-reviewed sources are written and edited by the **experts**.

Sources on the Web — like Wikipedia — are written by...well...who knows?

Internet writers

Health care professionals and researchers.

QUALITY

- Reviews drive **evidence-based clinical guidelines**.
- Applications:
  - **Oncology:** immune checkpoint inhibitors.
  - **Neurology:** Alzheimer's biomarkers.
  - **Cardiology:** statins in secondary prevention.
  - **Infectious disease:** COVID-19 antivirals/vaccines.

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Data Sharing and Open Science

- FAIR principles: **Findable, Accessible, Interoperable, Reusable**.

- Repositories: Zenodo, Dryad, Figshare.

- Importance: reproducibility, secondary analysis, machine learning applications.

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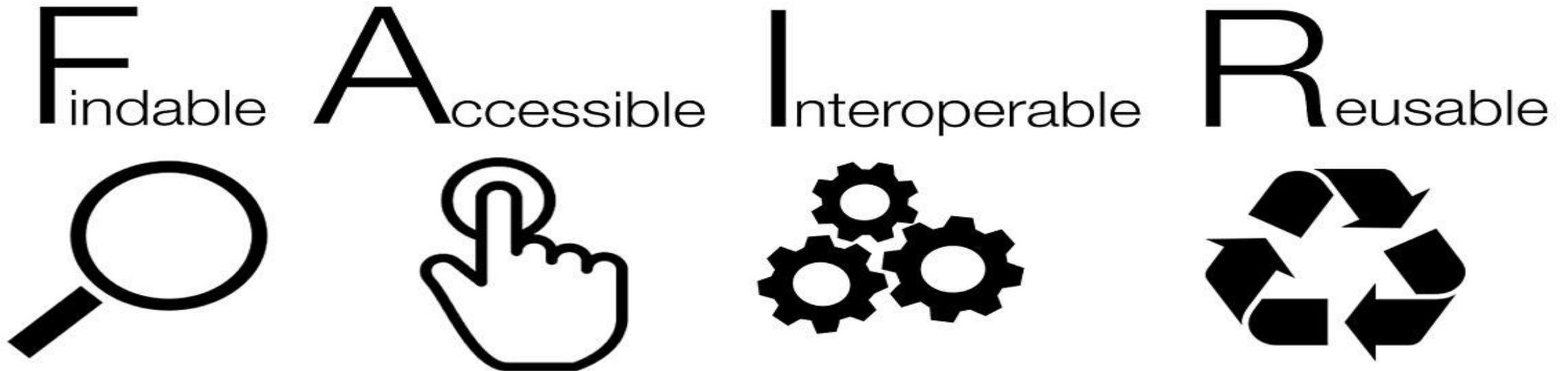
Writing a Systematic Review

- Follow **PRISMA 2020** and **AMSTAR-2**.
- Critical sections: Introduction, Methods (with full strategy), Results, Discussion, Limitations.
- Appendices: full search strategy, excluded studies with rationale.
- Ensure compliance with **ICMJE and EQUATOR Network** guidelines.

ICMJE INTERNATIONAL COMMITTEE of MEDICAL JOURNAL EDITORS

Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals
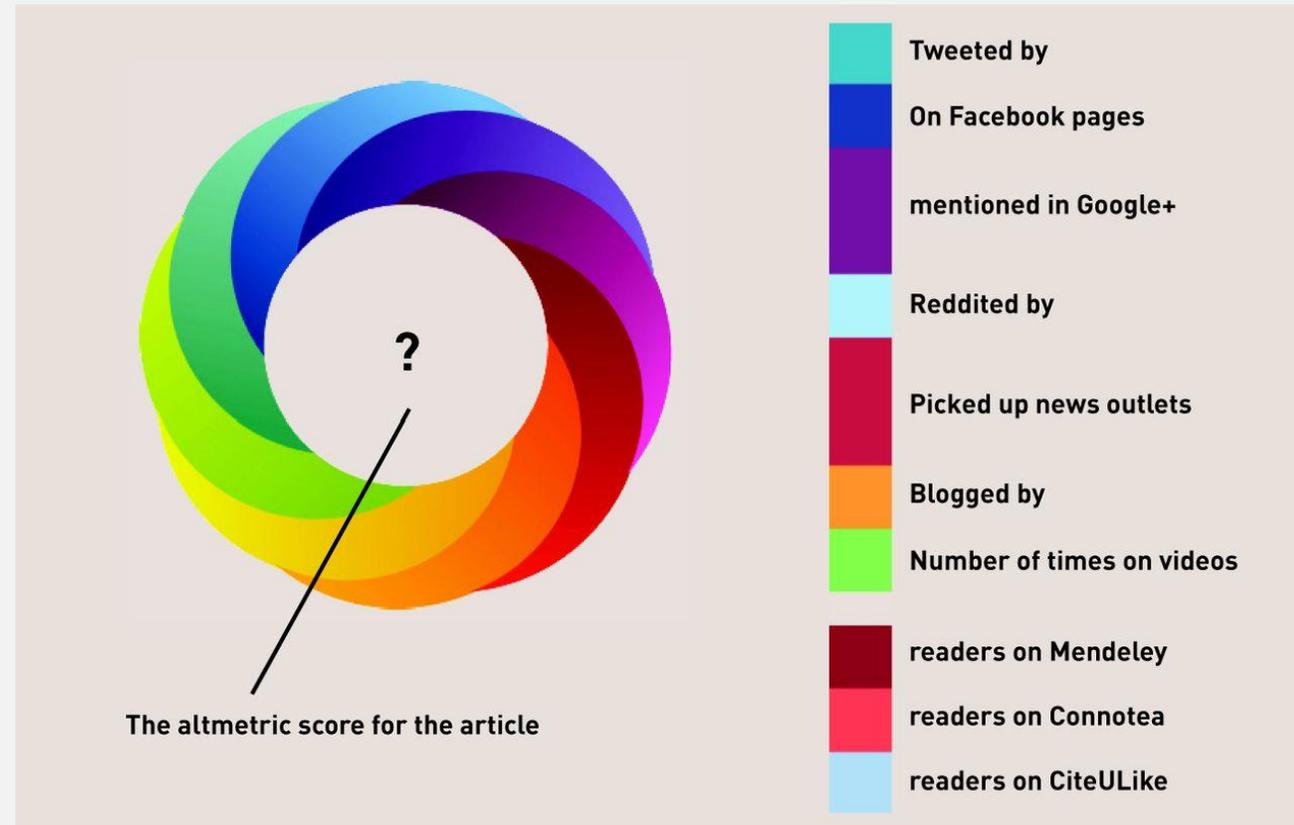
Updated January 2025

PRISMA

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Visualisation Tools

- **Forest plots:** Effect size and precision.
- **Funnel plots:** Bias assessment.
- **Network diagrams:** NMA relationships.
- **Heatmaps:** ibliometric clustering.

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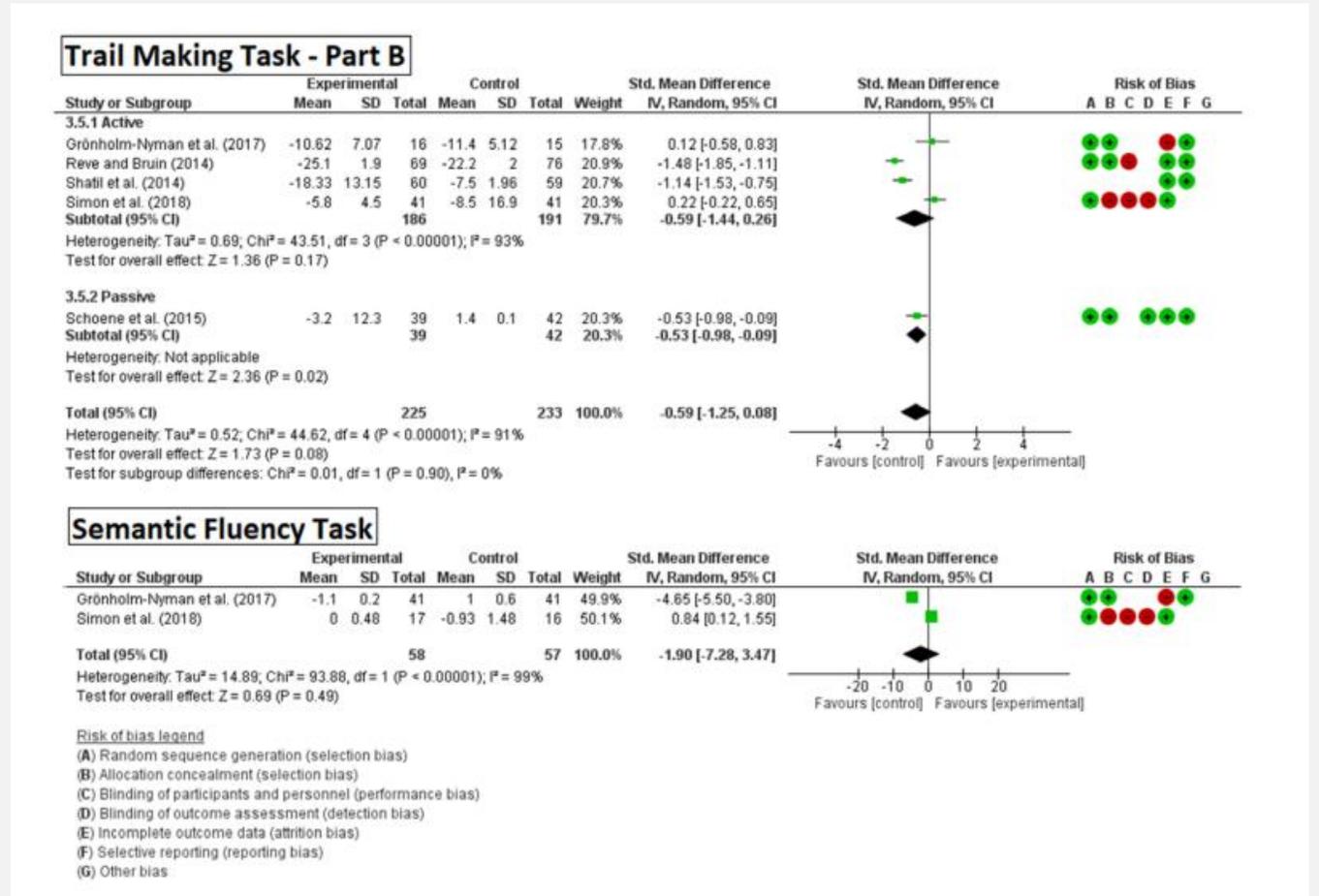
Bibliometric and Altmetric Integration

- **Bibliometrics:** traditional citation-based metrics.
- **Altmetrics:** mentions in Twitter (x), blogs, news outlets.
- Increasing importance in **translational dissemination**.

? The altmetric score for the article

Tweeted by
On Facebook pages
mentioned in Google+
Reddited by
Picked up news outlets
Blogged by
Number of times on videos
readers on Mendeley
readers on Connotea
readers on CiteULike

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Emerging Trends

- **Living systematic reviews** with continuous AI-updated evidence.

- **AI-assisted screening** (e.g., natural language processing for abstracts).

- **Integration with omics data:** genomics, proteomics, metabolomics.

- Hybrid **systematic review + bibliometric analysis** designs.

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Practical Tips for Researchers

- Register early in **PROSPERO/OSF**.

- Involve **information specialists/librarians**.

- Use reproducible pipelines (R Markdown, Jupyter).

- Preprint protocols and reviews for transparency.

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Conclusion

- Reviews provide the **highest level of synthesis in evidence hierarchies**.

- Statistical formalism increases robustness and reproducibility.

- Bibliometric reviews complement SRs by mapping research dynamics.

- Future: **AI + open science + biomolecular integration**.

Evidence-Based Medicine $= f$(Clinical Trials, Systematic Reviews, Molecular Data, Open Science)

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