

zen and the art of scientific synthesis

@cjlortie



The pencil is mightier than the pen.

Pirsig



We can see the entire universe in our breakfast cereal.

Allendorf



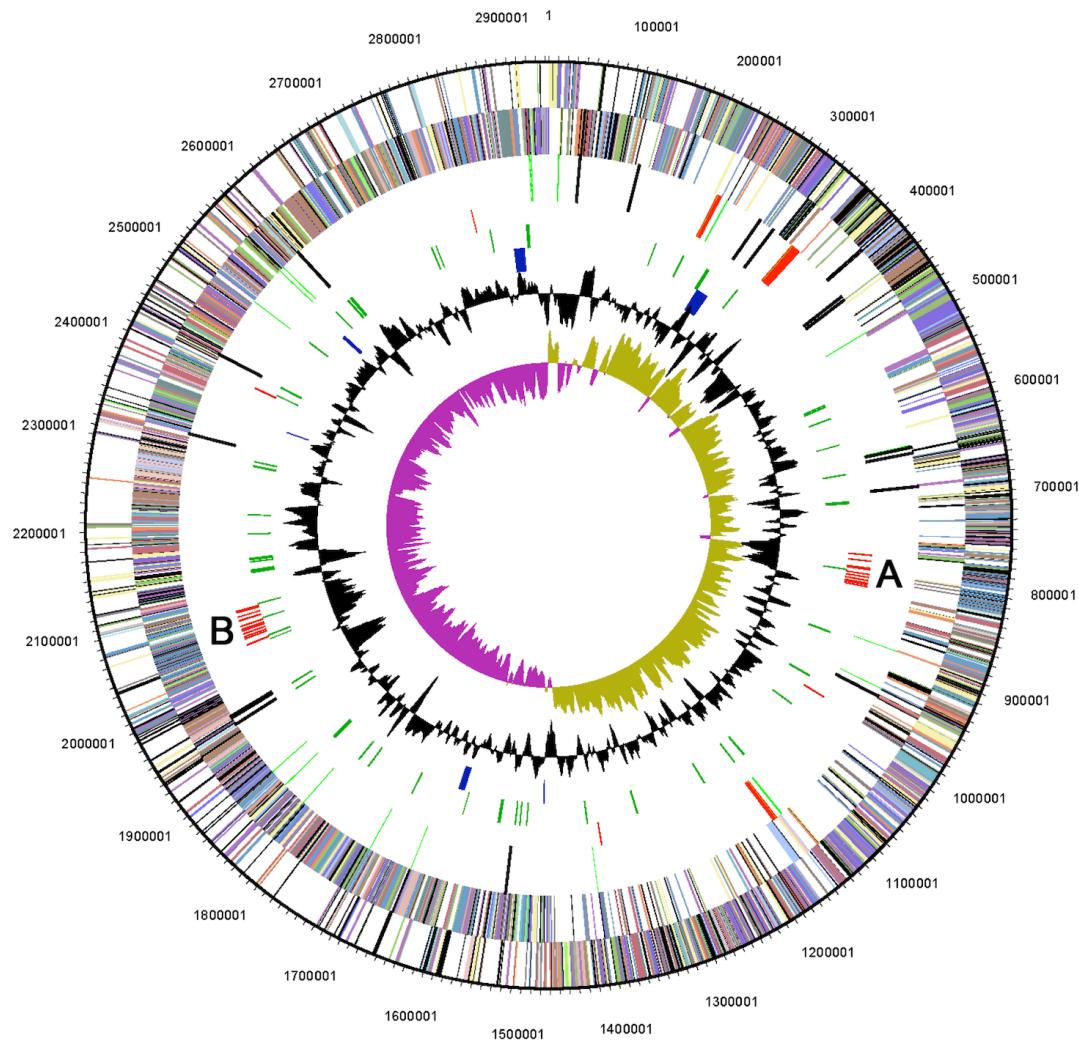
We absolutely need the mechanics & the connections,  
but we also need the big picture.

zen

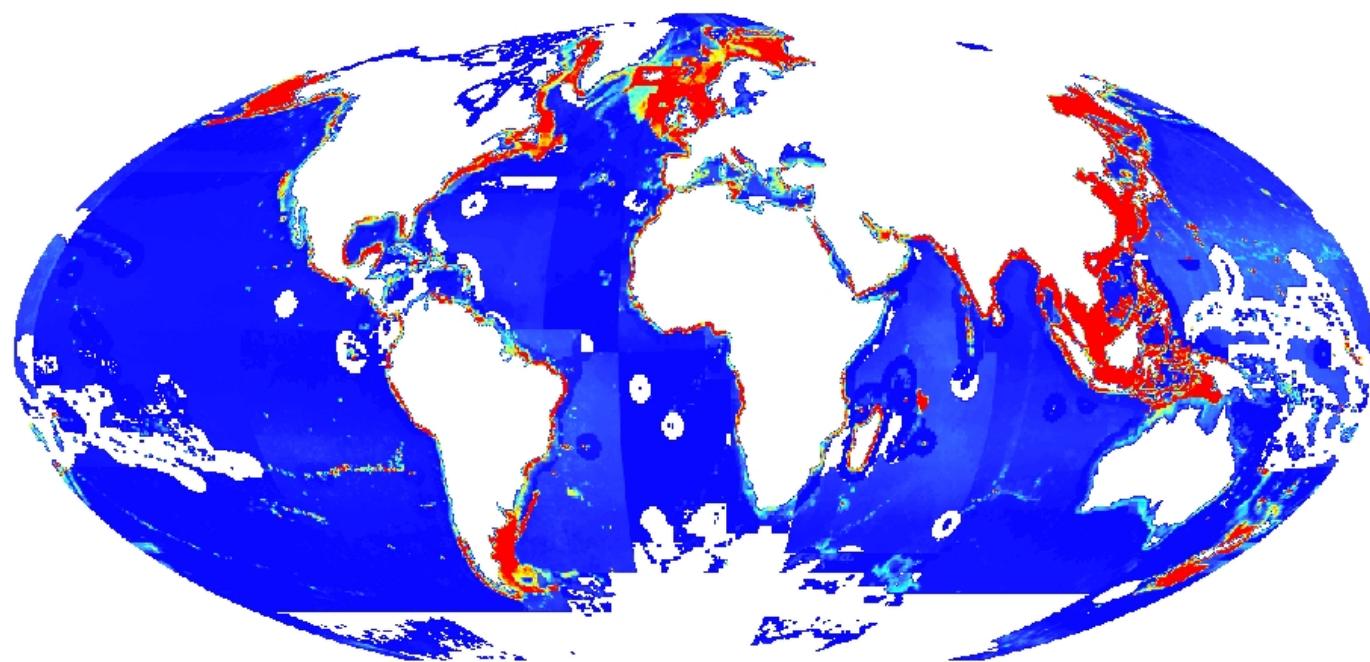


zen is a way of being that incorporates total togetherness  
of mind and body

synthesis



synthesis is the combination of two or more entities



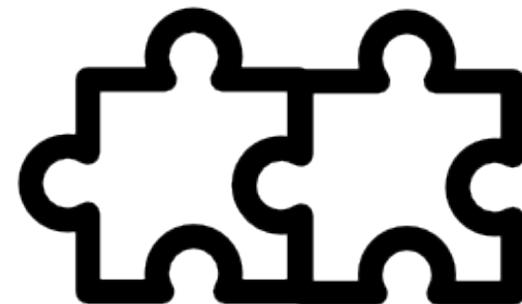
scientific synthesis is the integration of evidence

zen and scientific synthesis connect

mind = synthesis



body = data



dynamic solutions



scientific synthesis is part of the process &  
completes the knowledge loop

why?



what connects & what matters

combine & mine disparate datasets  
develop novel insight tools  
integrate theoreticians,  
practitioners, & modelers  
link to education.& application

## data

counterweight  
to hyper-specialization

copes with  
data deluge

## synthesis

diversity  
promotes  
discovery

conceptualizes  
complexity

controlled vocabulary

scientific synthesis

synthesis will shift your view of statistical significance

# Today's Random Medical News

from the New England  
Journal of  
Panic-Inducing  
Gobbledygook

JIM BISHOP



significant evidence

not significant p-values

what is a p-value?

when is a p-value appropriate?

what are good solutions?

p-value is the measure of strength of evidence against the null hypothesis.

Smaller values the stronger the evidence against null.

unfortunately, the p-value used in environmental science is the Type I error rate.

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**Table 1** Possible errors in interpretation of experiments, according to the Neyman-Pearson approach to hypothesis testing. Error rates are proportion of times that type I and type II errors occur in the long run

Result of experiment	The truth	
	Null hypothesis true (treatment doesn't work)	Null hypothesis false (treatment works)
Reject null hypothesis	Type I error rate	Power=1-type II error rate
Accept null hypothesis		Type II error rate

why does using p-values matter?



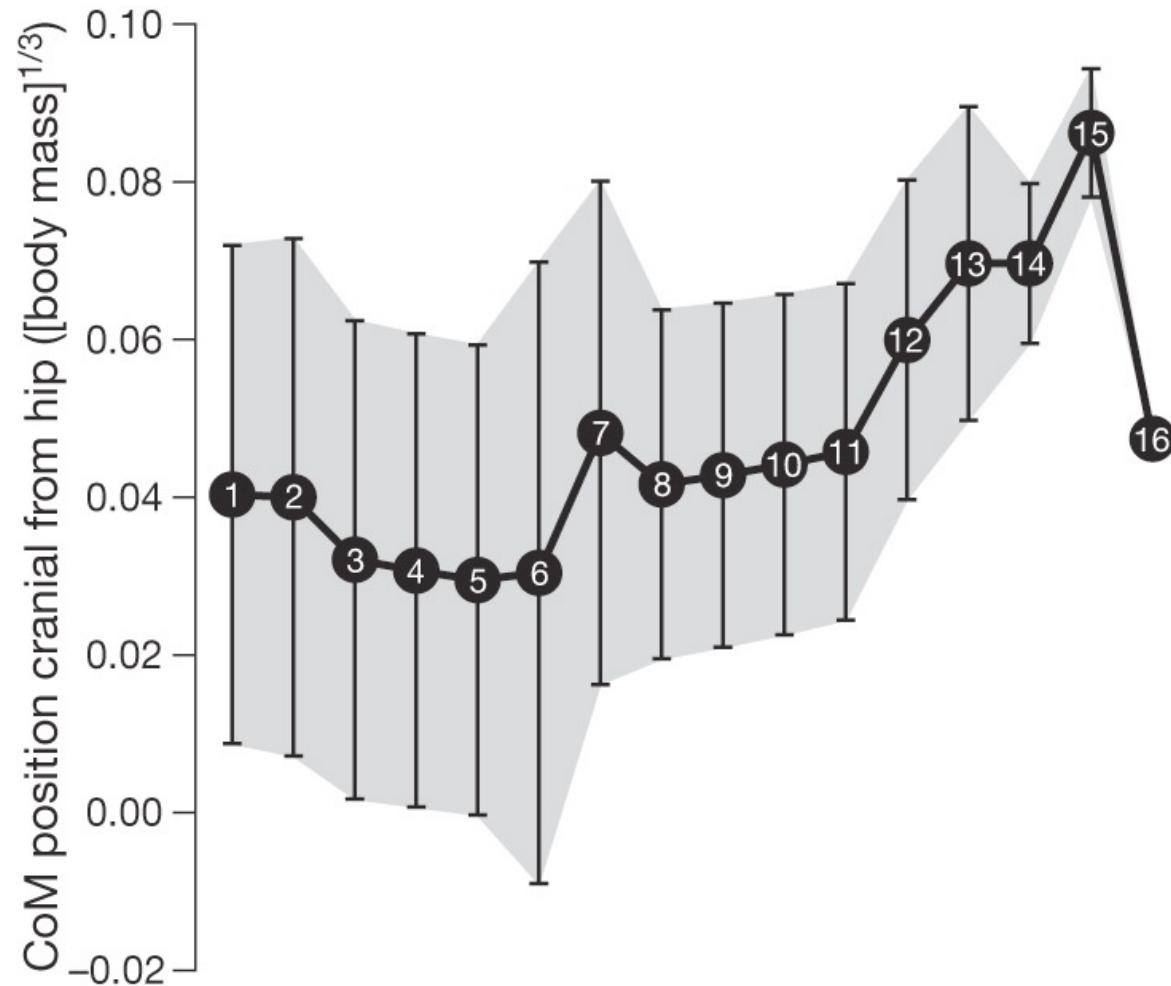
no strength of evidence conveyed, i.e. treatment strength.

# why does using p-values matter?



scales up to population level false positives

p-values are acceptable if ... there are not a large population of studies, the experiment is very controlled, and the value is very, very low.



provides a plausible range.

## solutions

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present precise p-value

interpret based on context, experiment, & evidence

do not interpret as significant/non-significant

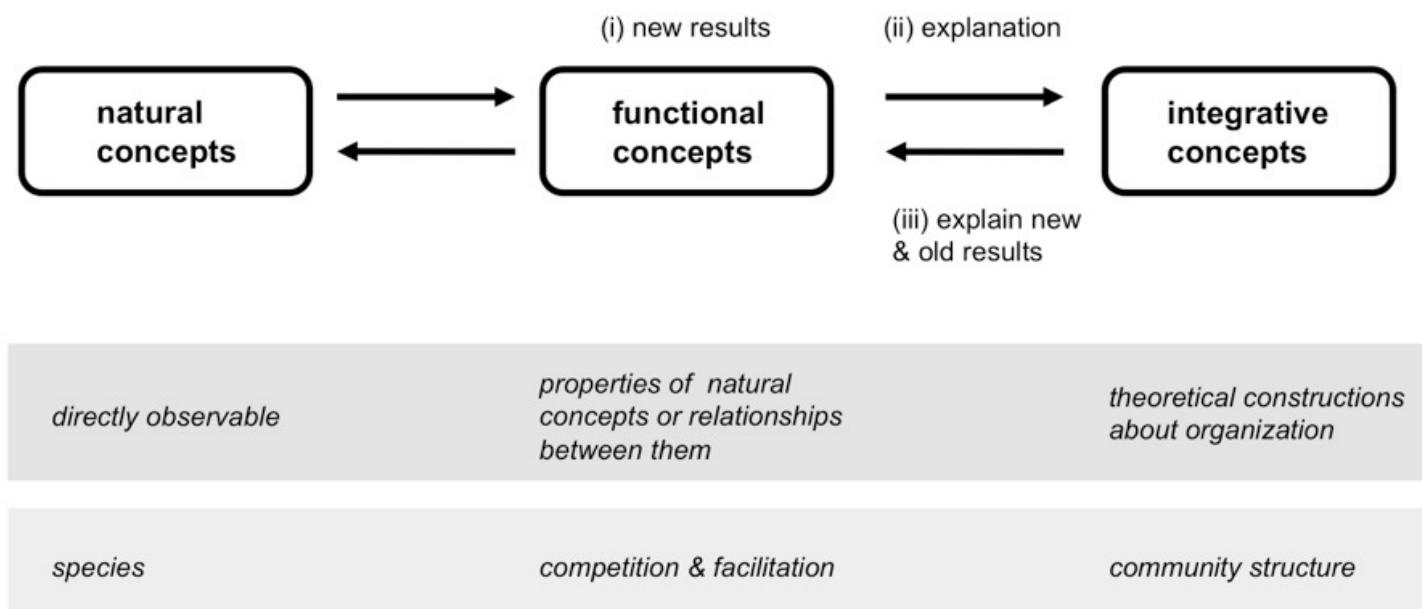
report strength of effects

show confidence intervals

synthesis will refine your conceptual understanding of a topic



# synthesis framing



# synthesis tools

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textbook examples

narrative reviews

vote counting

combining probabilities

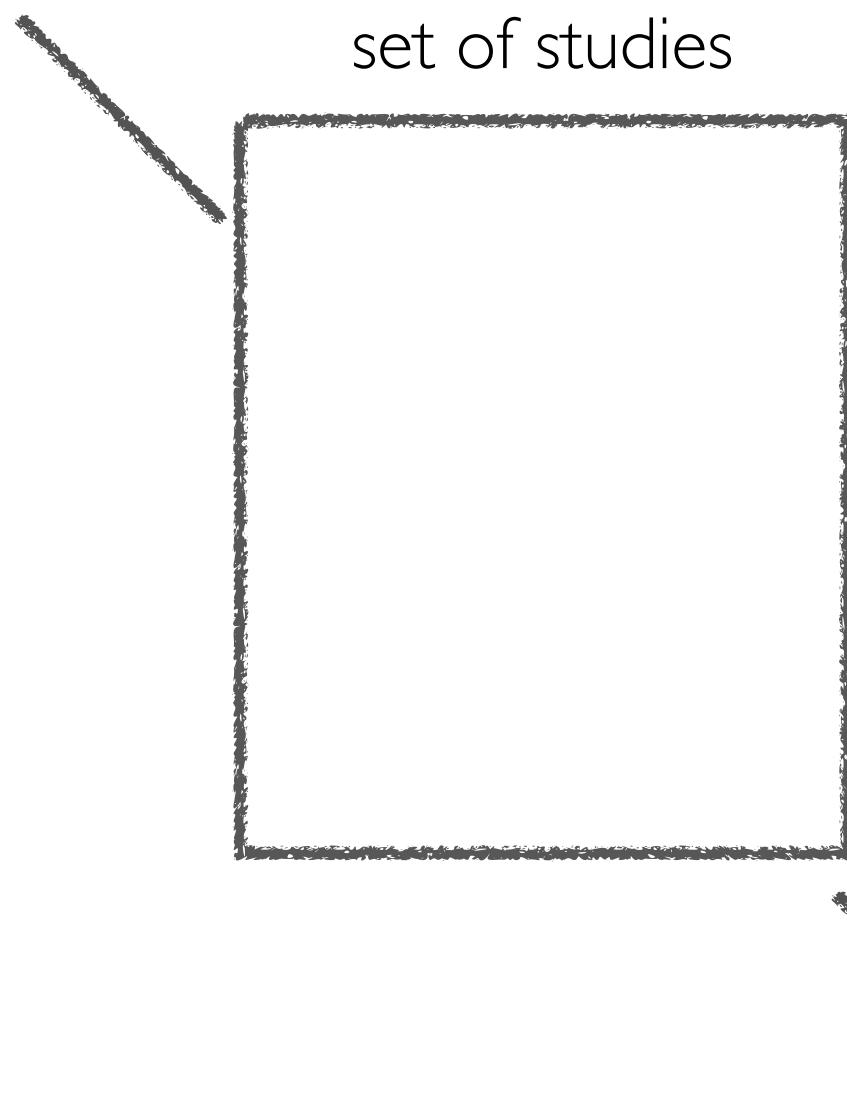
systematic reviews

meta-analysis

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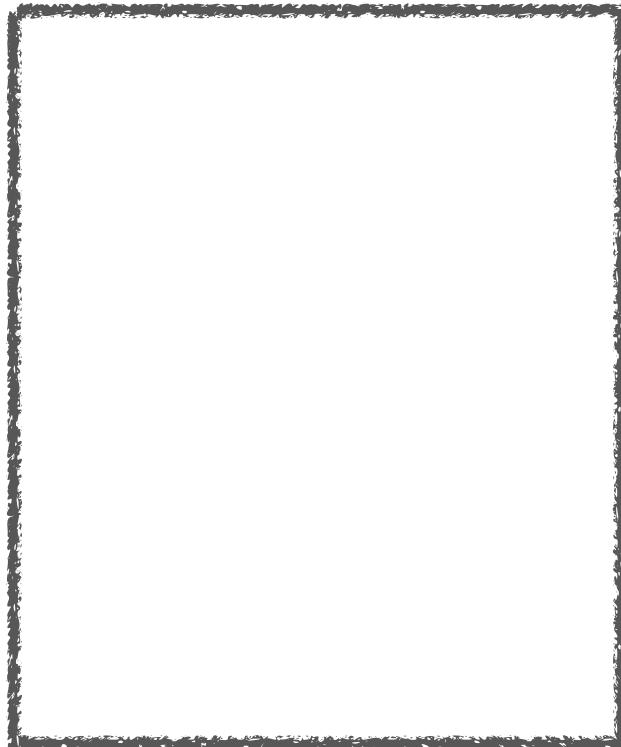
	narrative	vote	probability	meta
study restriction	no	no	no	yes
statistical significance	yes	yes	yes	no
n & power	no	no	yes	yes
mean effect	no	no	yes	yes
magnitude of effect	no	no	no	yes
variation	no	no	no	yes

hypothesis or problem



predictions or queries

set of studies



predictions

- i. summarize knowledge
- ii. meta-analysis

## information management shifts

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publications & datasets are critical sources of information

meta-analyses are powerful

systematic reviews synthesize knowledge

important for application & management

influences how you process primary research

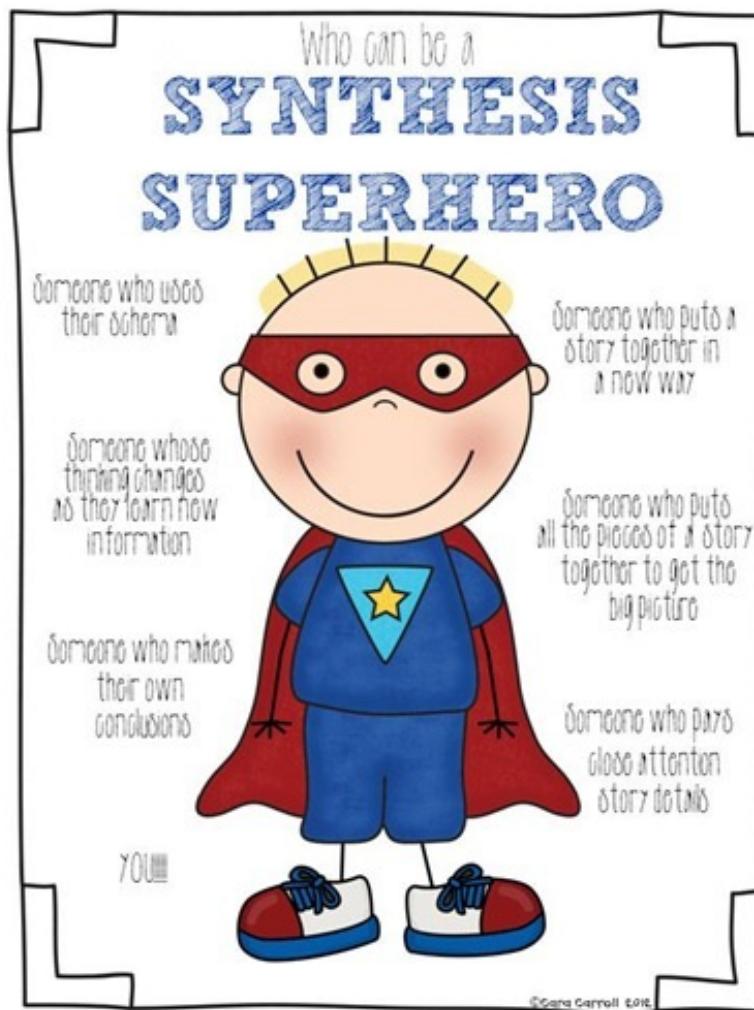
challenges notion of significance



systematic reviews & meta-analyses are a very quick way to get up to speed on a topic

synthesis will facilitate assessment of research landscape & evidence

research landscape = systematic review

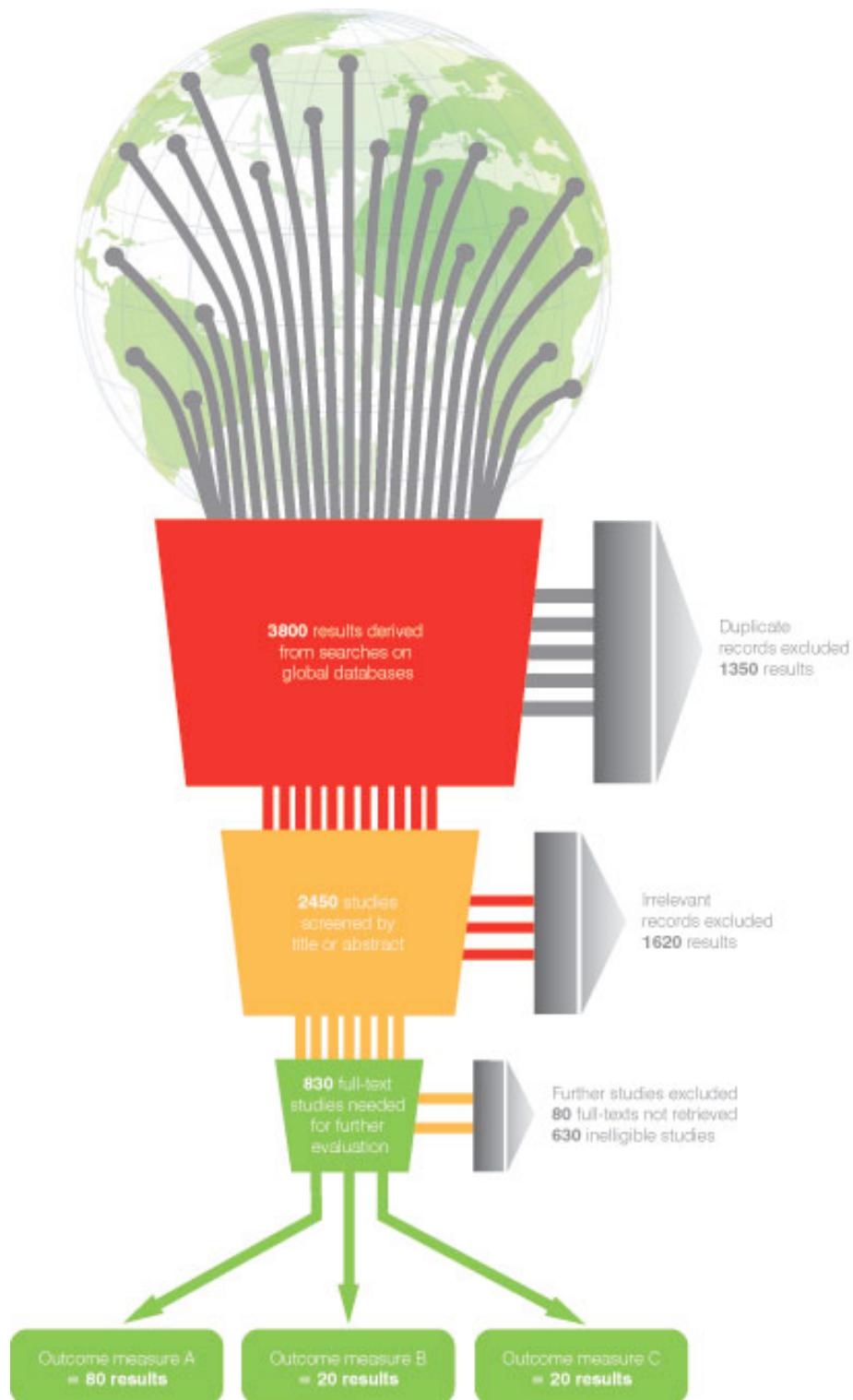


evidence = meta-analysis

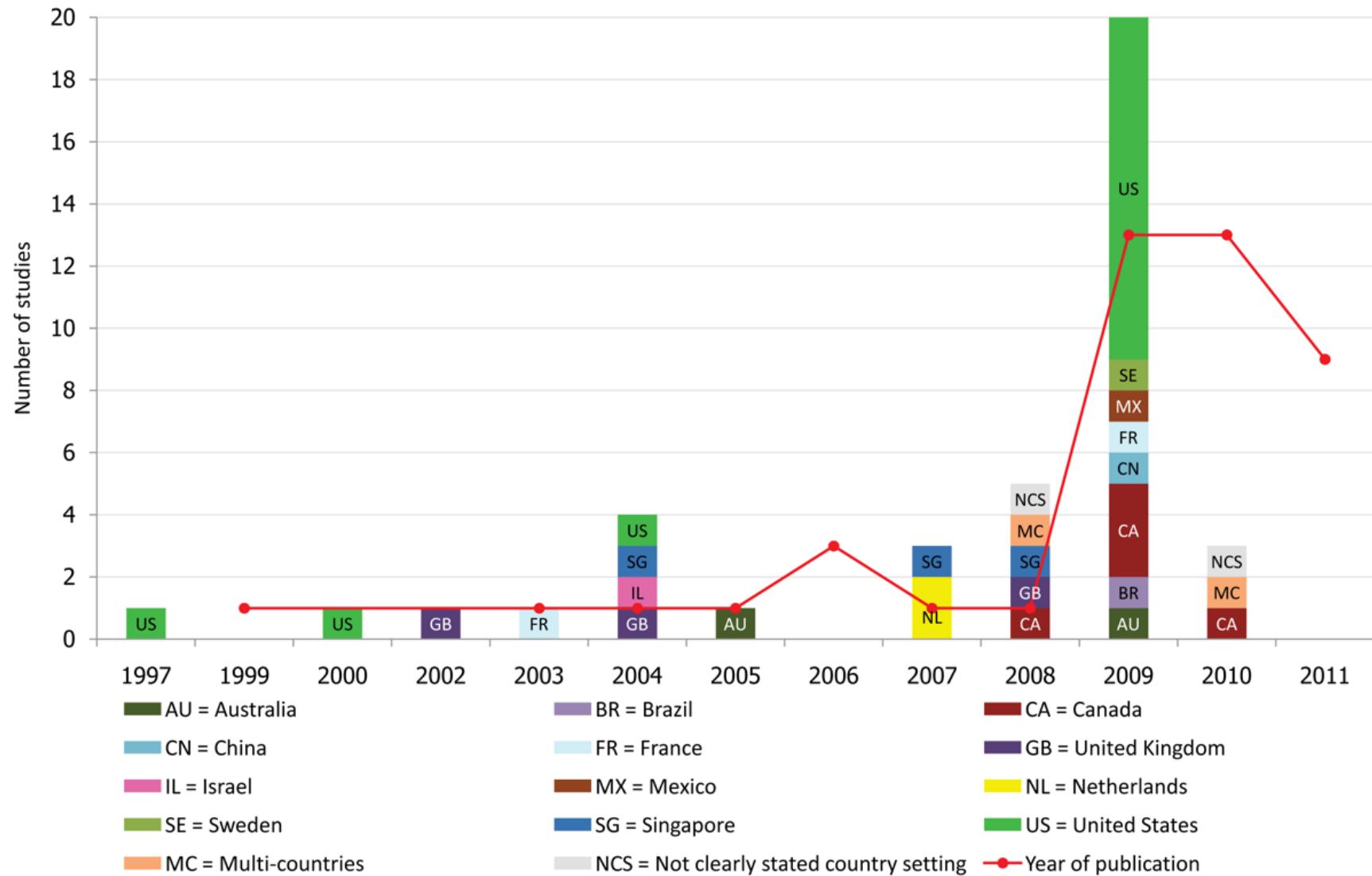
# systematic reviews

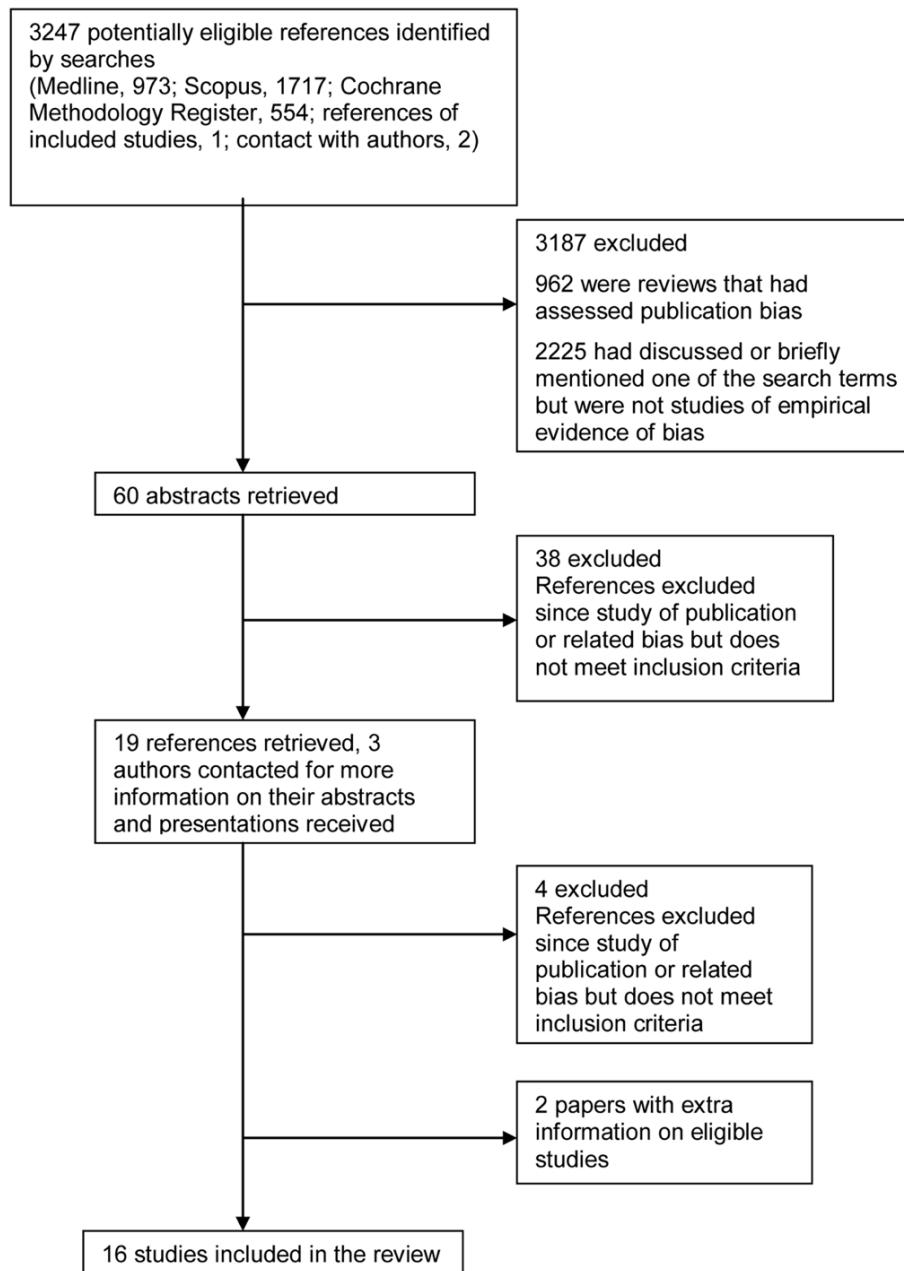


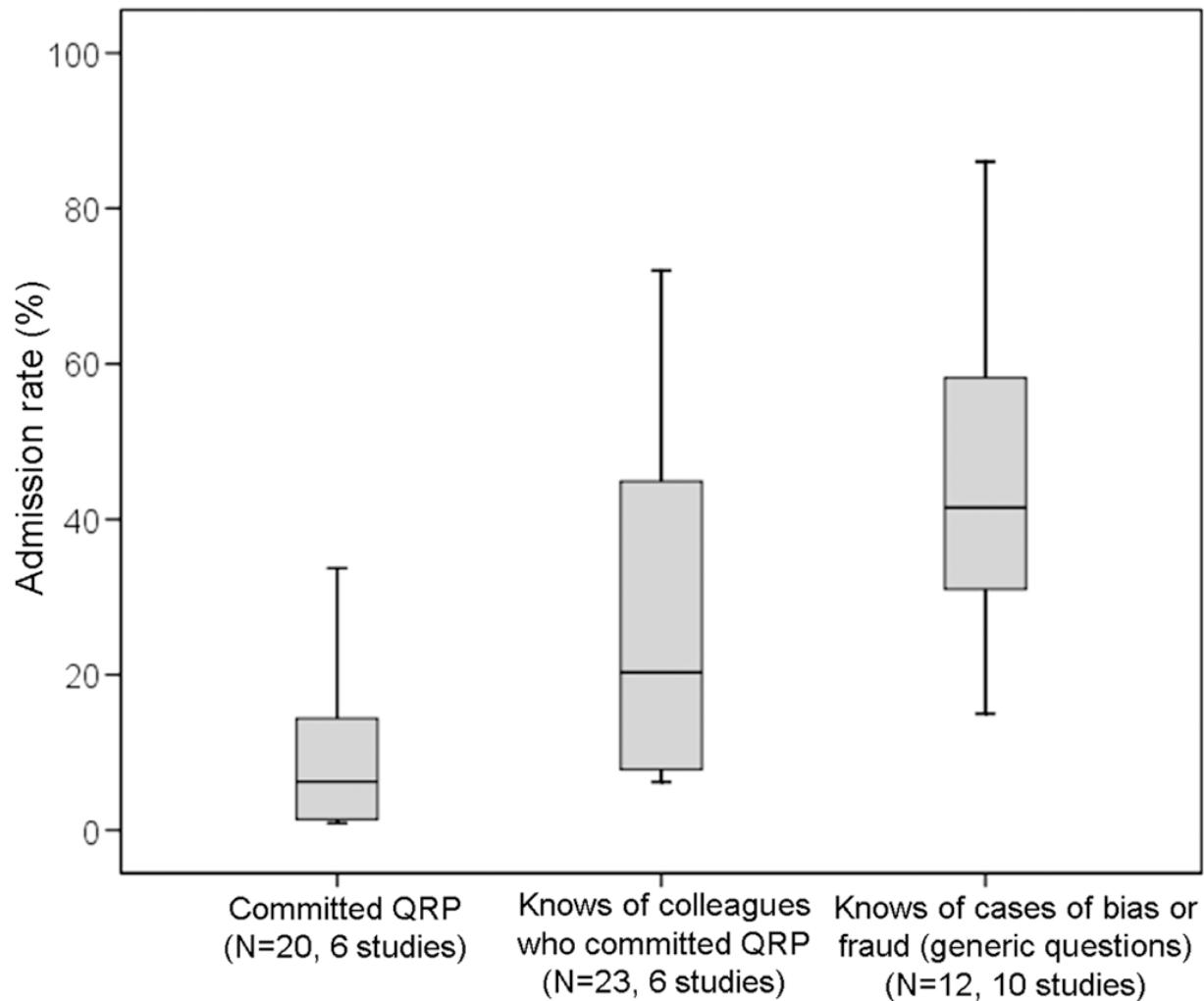
The Cochrane Collaboration



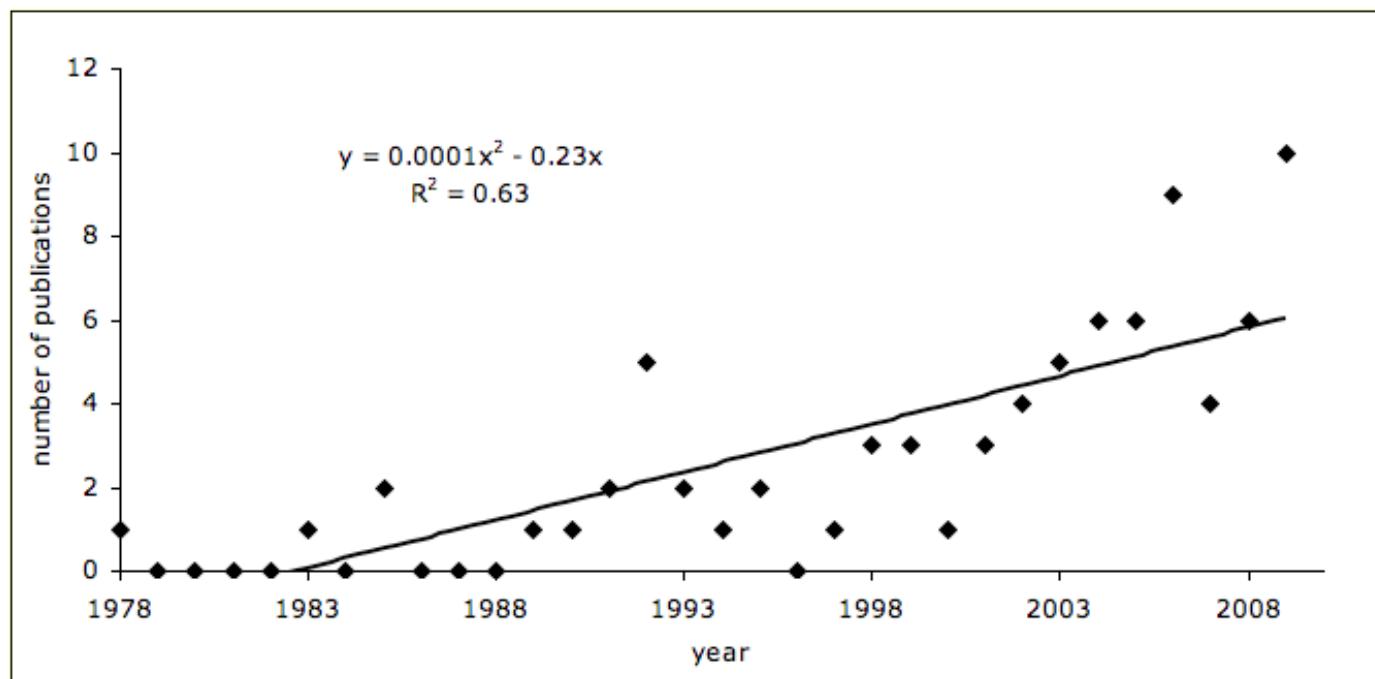
A systematic review attempts to identify, appraise and synthesize all the empirical evidence that meets pre-specified eligibility criteria to answer a given research question. Researchers conducting systematic reviews use explicit methods aimed at minimizing bias, in order to produce more reliable findings that can be used to inform decision making.



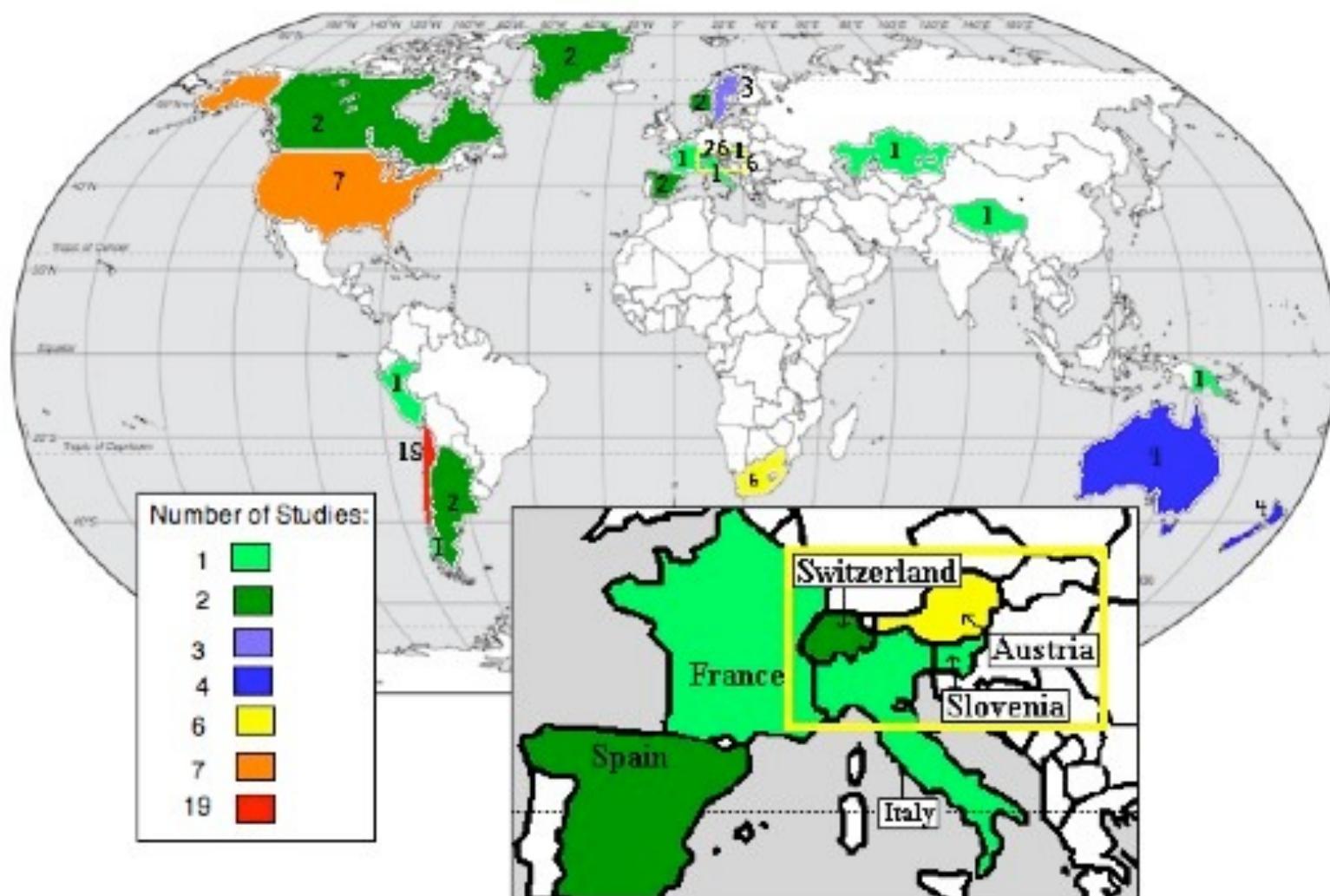




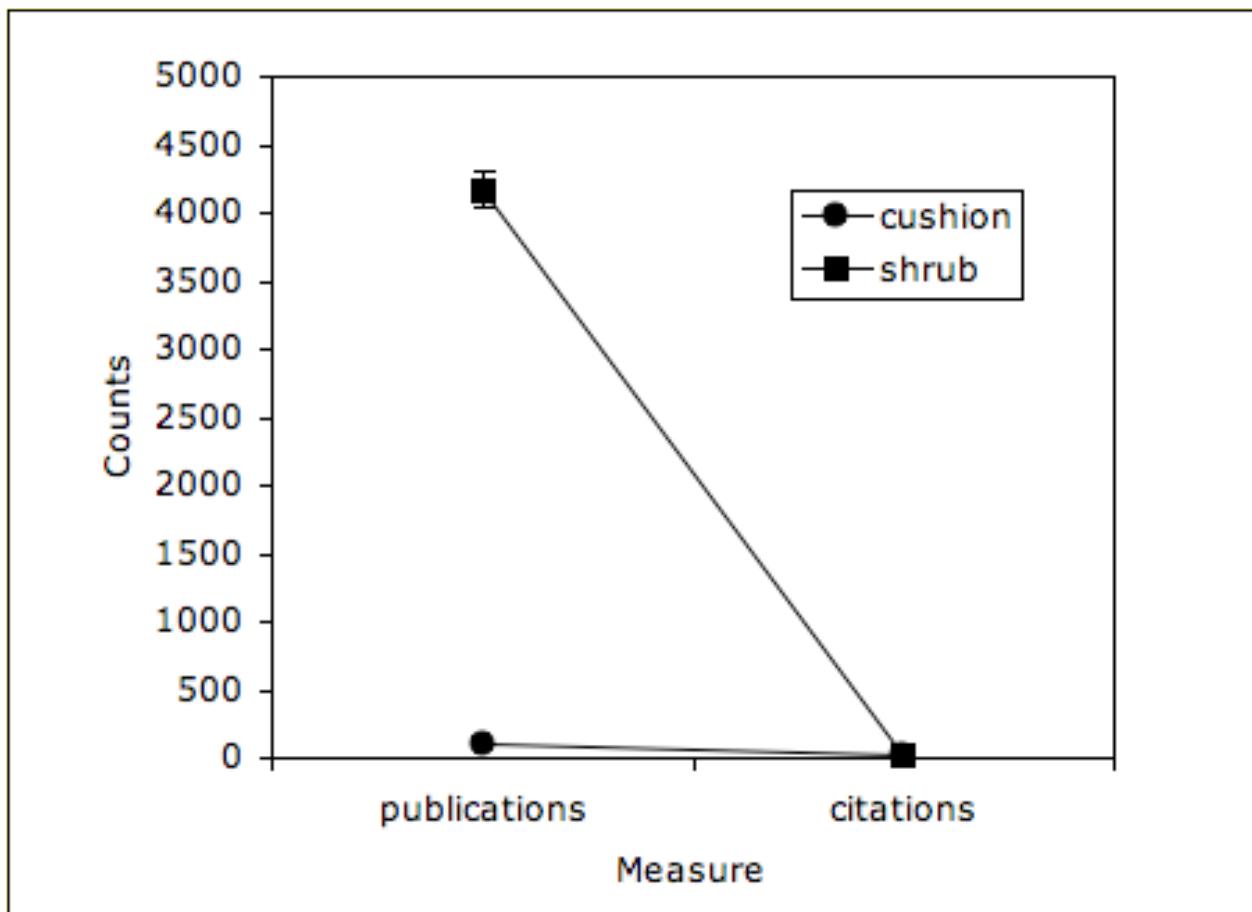
rate



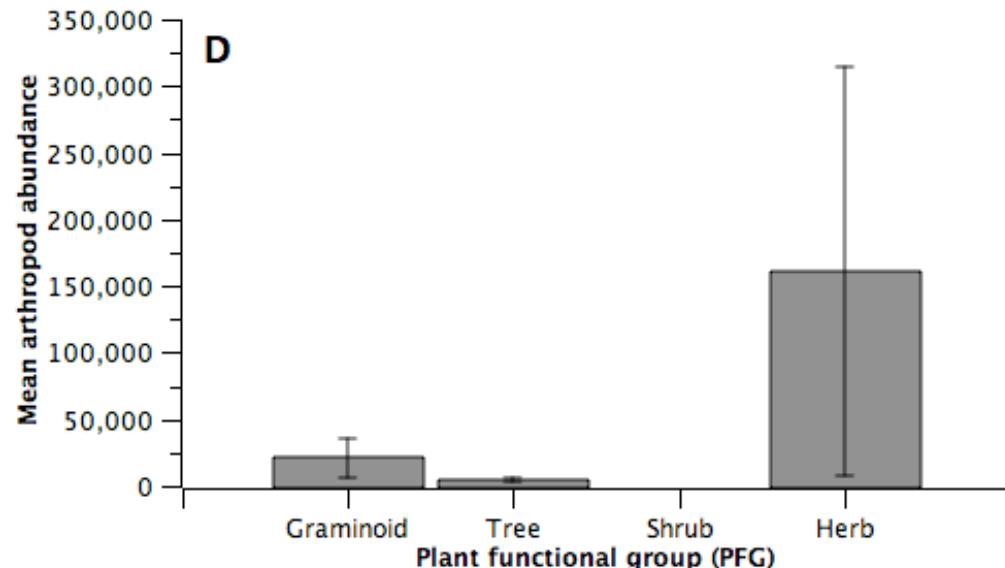
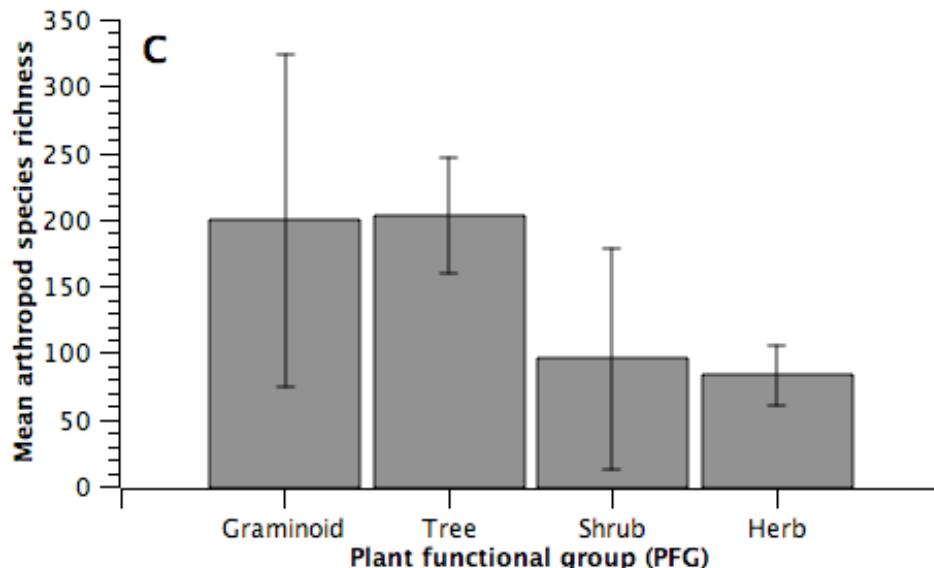
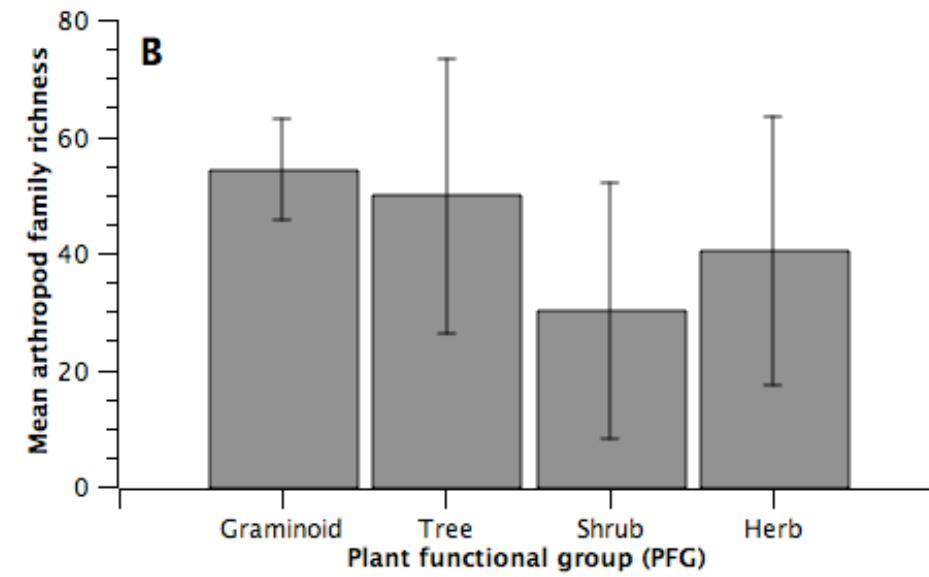
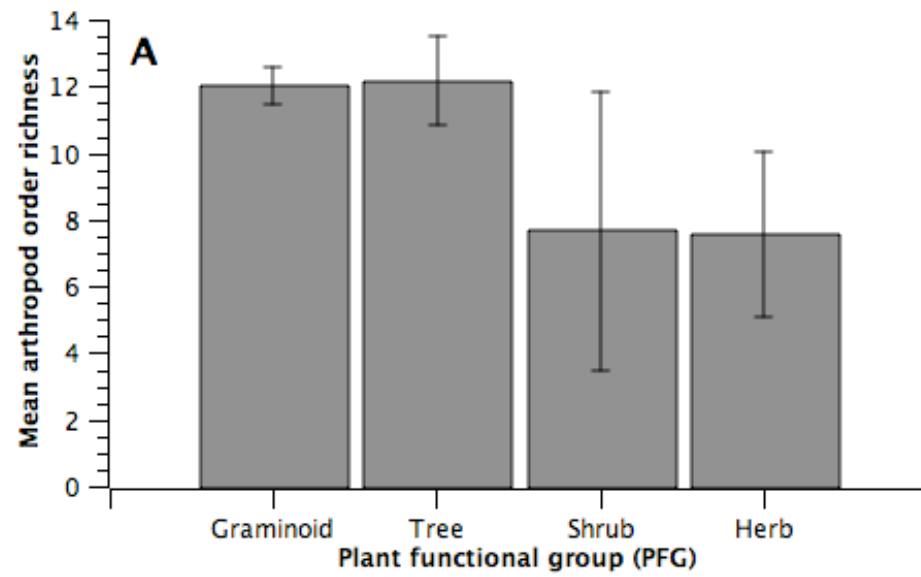
where



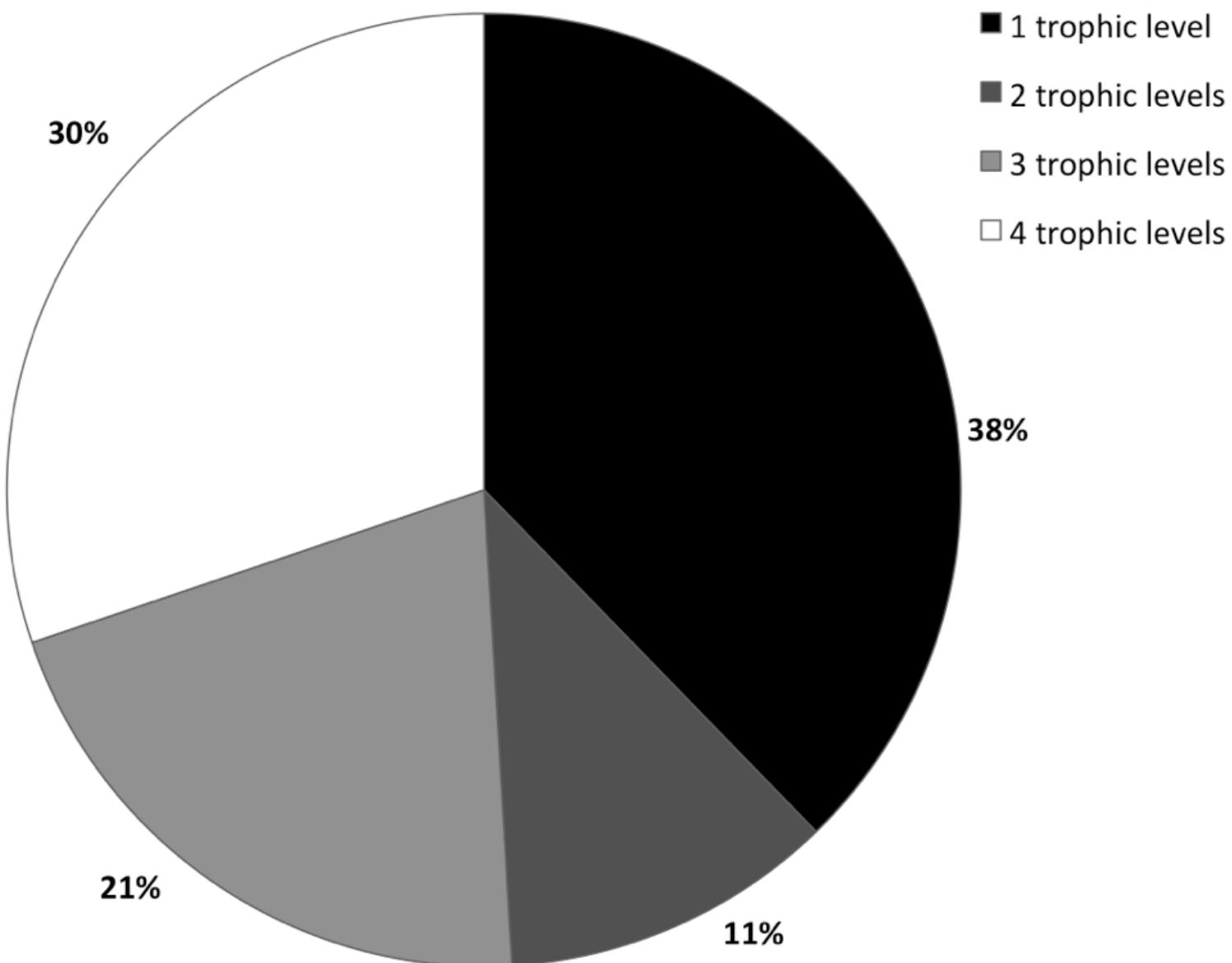
citations



# diversity or n of subjects



## complexity within studies



# PRISMA

A systematic review is a review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyze data from the studies that are included in the review. Statistical methods (meta-analysis) may or may not be used to analyze and summarize the results of the included studies. Meta-analysis refers to the use of statistical techniques in a systematic review to integrate the results of included studies.

<http://www.prisma-statement.org/statement.htm>

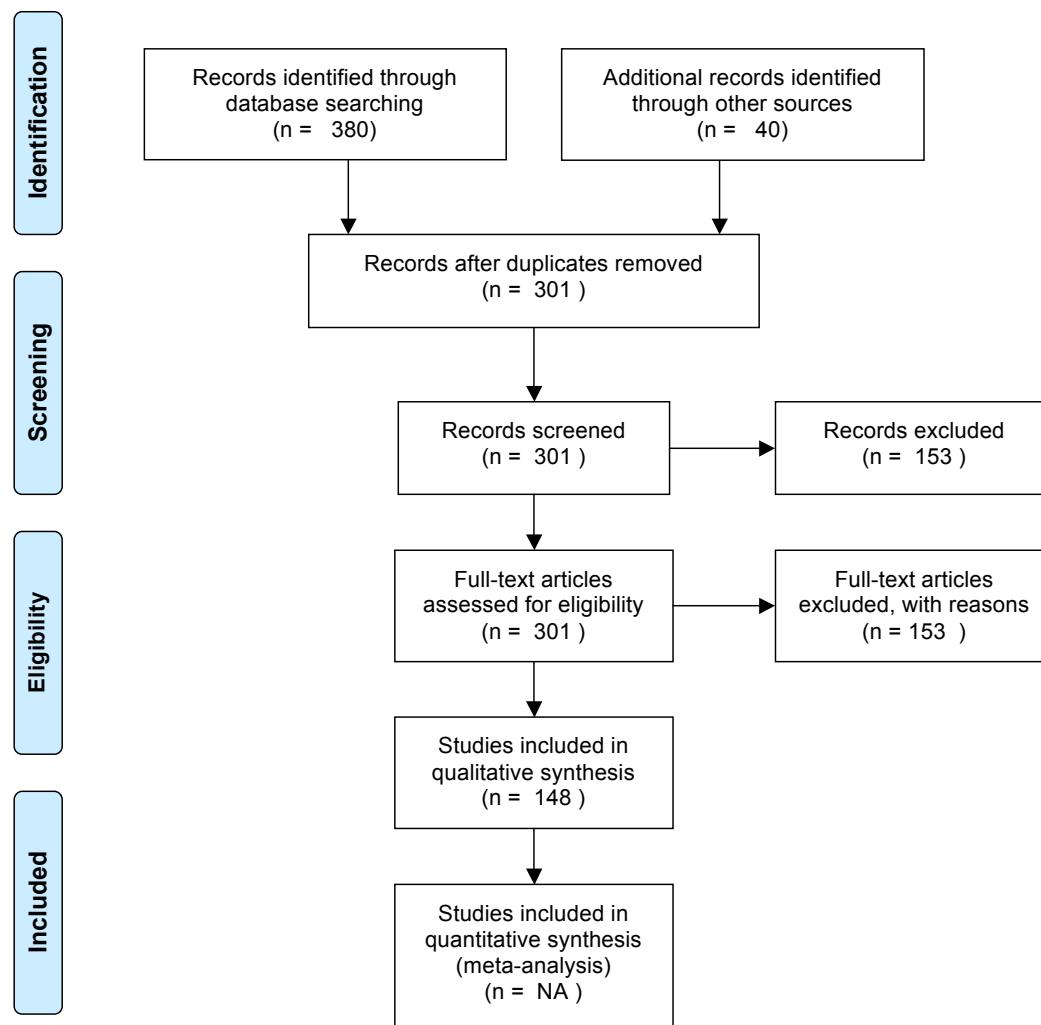
# PRISMA



transparency & replicability



## PRISMA 2009 Flow Diagram



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed.1000097

For more information, visit [www.prisma-statement.org](http://www.prisma-statement.org).



## PRISMA 2009 Checklist

Section/topic	#	Checklist item	Report on page
<b>TITLE</b>			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
<b>ABSTRACT</b>			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
<b>INTRODUCTION</b>			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2 – 4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5 – 6
<b>METHODS</b>			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	NA
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5 – 6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	5
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5 – 6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., $I^2$ ) for each meta-analysis.	6

initial scoping

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variety of terms

multiple databases

## develop a search strategy

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wildcards

do not truncate

avoid ambiguity

common names

define inclusion criteria

document process & double-check

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# gaps

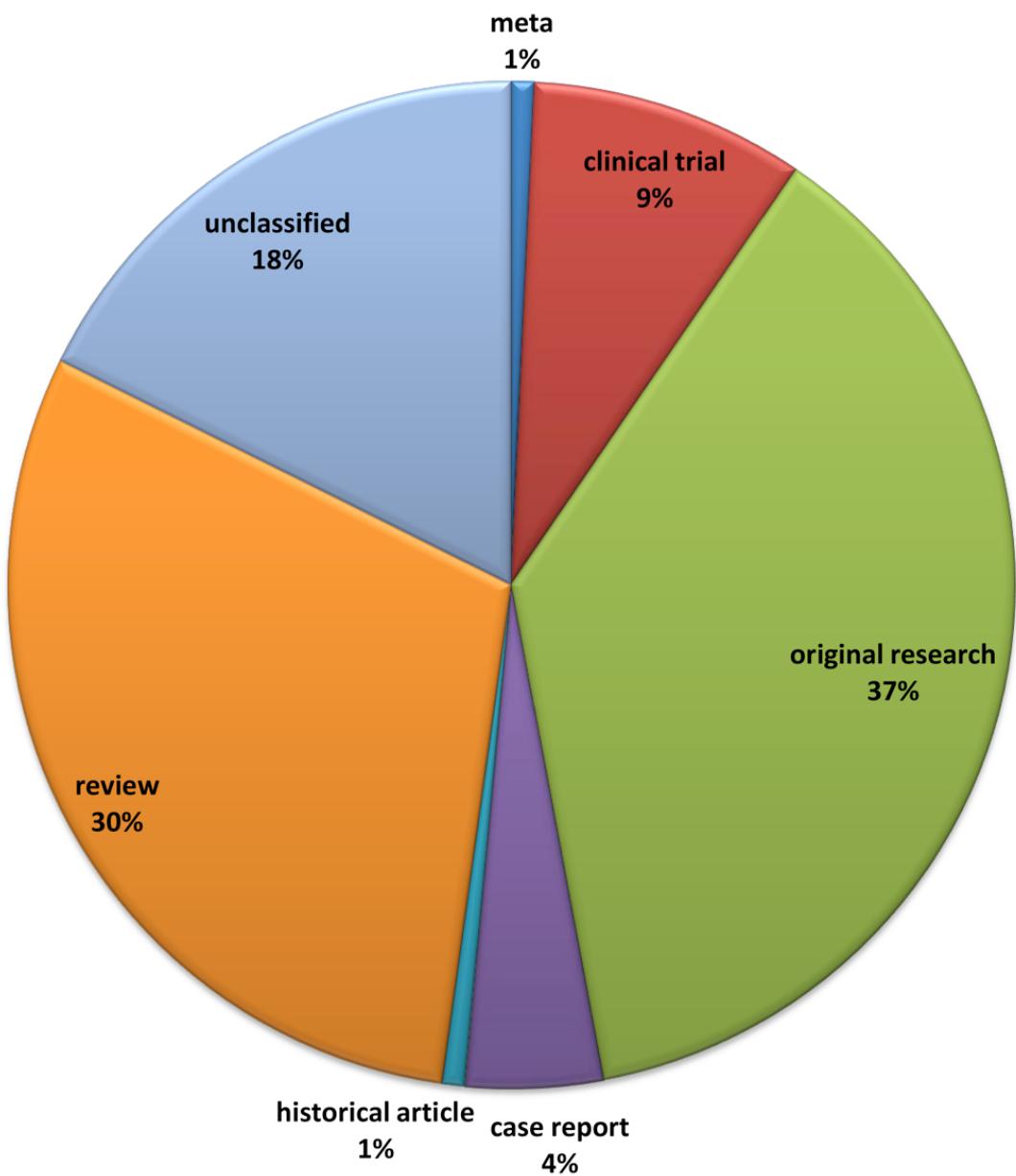
## A Pharmacodynamic

	APOE	ACE	ADRB2	HLA-B	HTR*	DRD2	F5	TNF	HLA-DRB1	VDR
1. Gastroenterology	2	0	0	0	0	0	0	5	1	0
2. Cardiovascular	29	79	4	0	2	0	7	1	1	0
3. Respiratory	0	0	34	0	0	0	0	0	0	0
4. CNS	31	2	0	12	27	27	0	2	1	0
5. Infections	1	0	0	11	0	0	0	1	1	0
6. Endocrine	10	3	1	0	0	1	2	2	3	7
7. Obstetrics/Gynaecology	1	0	0	0	0	0	12	0	0	0
8. Malignant/Immunosuppression	1	0	0	0	0	0	0	4	8	2
9. Nutrition/Blood	4	0	0	0	0	0	0	0	0	9
10. Muscle/Joint	5	0	0	1	0	0	0	4	6	0
11. Eye	0	0	0	0	0	0	0	0	0	0
12. ENT	0	0	3	0	0	0	0	0	0	0
13. Skin	1	0	0	0	0	0	0	1	0	3
14. Vaccine	0	0	0	1	0	0	0	3	1	0
15. Anaesthesia	1	0	0	0	0	0	0	0	0	0

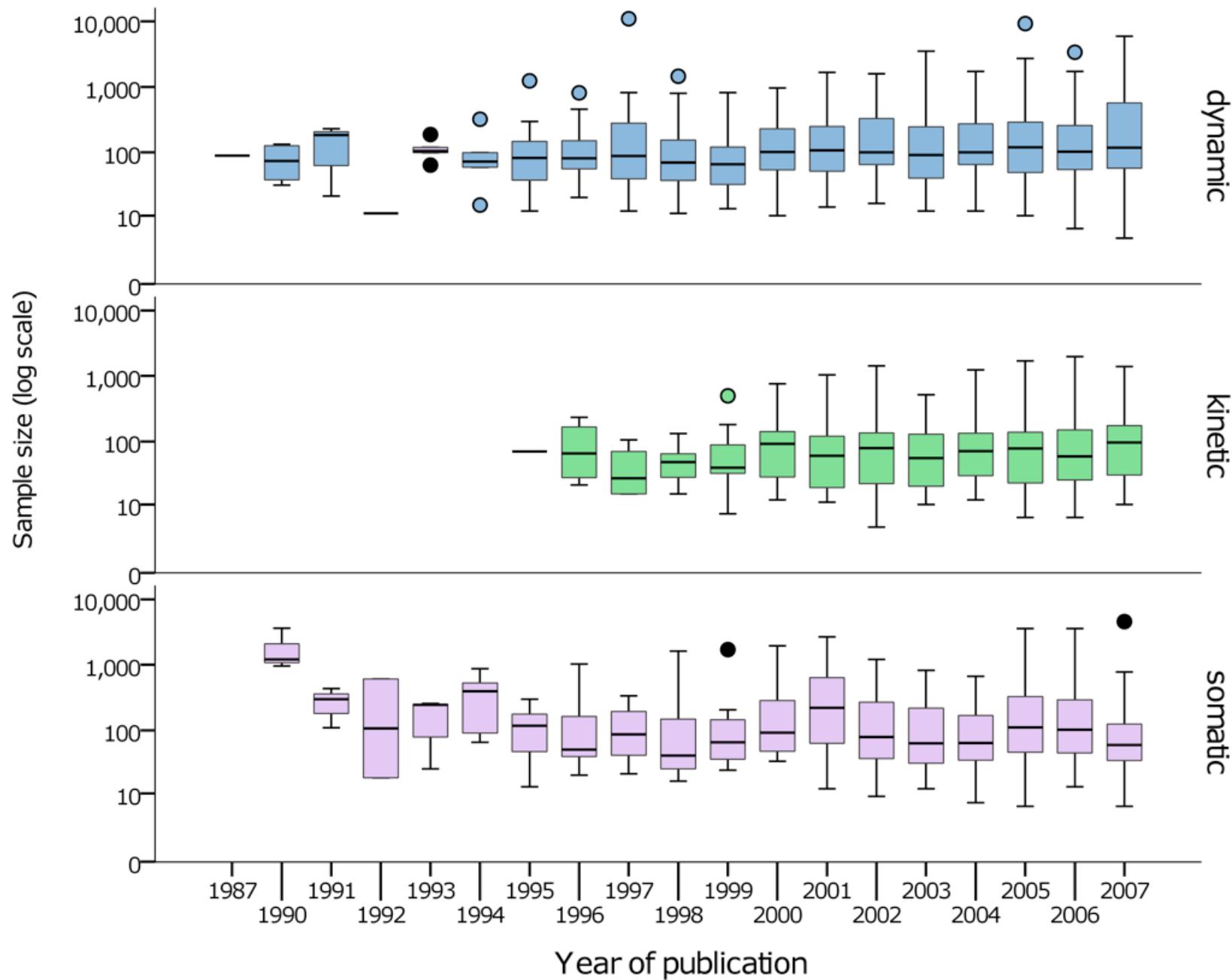
## B Pharmacokinetic

	CYP2D6	CYP2C19	ABCB1	CYP2C9	MTHFR	CYP3A5	TPMT	UGT1A1	CYP3A4	CYP2B6
1. Gastroenterology	0	52	2	0	0	0	1	0	0	0
2. Cardiovascular	11	4	12	33	4	6	0	1	4	0
3. Respiratory	3	1	1	0	0	0	0	0	0	0
4. CNS	74	23	8	10	0	4	0	2	5	5
5. Infections	2	21	29	0	0	11	1	3	8	15
6. Endocrine	0	2	2	3	1	1	0	0	1	0
7. Obstetrics/Gynaecology	1	0	0	0	0	0	0	0	0	0
8. Malignant/Immunosuppression	4	3	22	3	15	16	29	23	10	1
9. Nutrition/Blood	0	0	1	0	41	0	0	1	0	0
10. Muscle/Joint	1	0	0	12	1	0	0	1	0	0
11. Eye	0	0	0	0	0	0	0	0	0	0
12. ENT	0	0	0	0	0	0	0	0	0	0
13. Skin	1	0	0	0	0	0	0	0	0	0
14. Vaccine	0	0	0	0	0	0	0	0	0	0
15. Anaesthesia	0	0	0	0	0	0	0	1	0	0

gaps



# gaps



evidence = meta-analysis

A meta-analysis is a systematic review (to some extent) that includes strength of evidence.

- usually an effect size estimate.

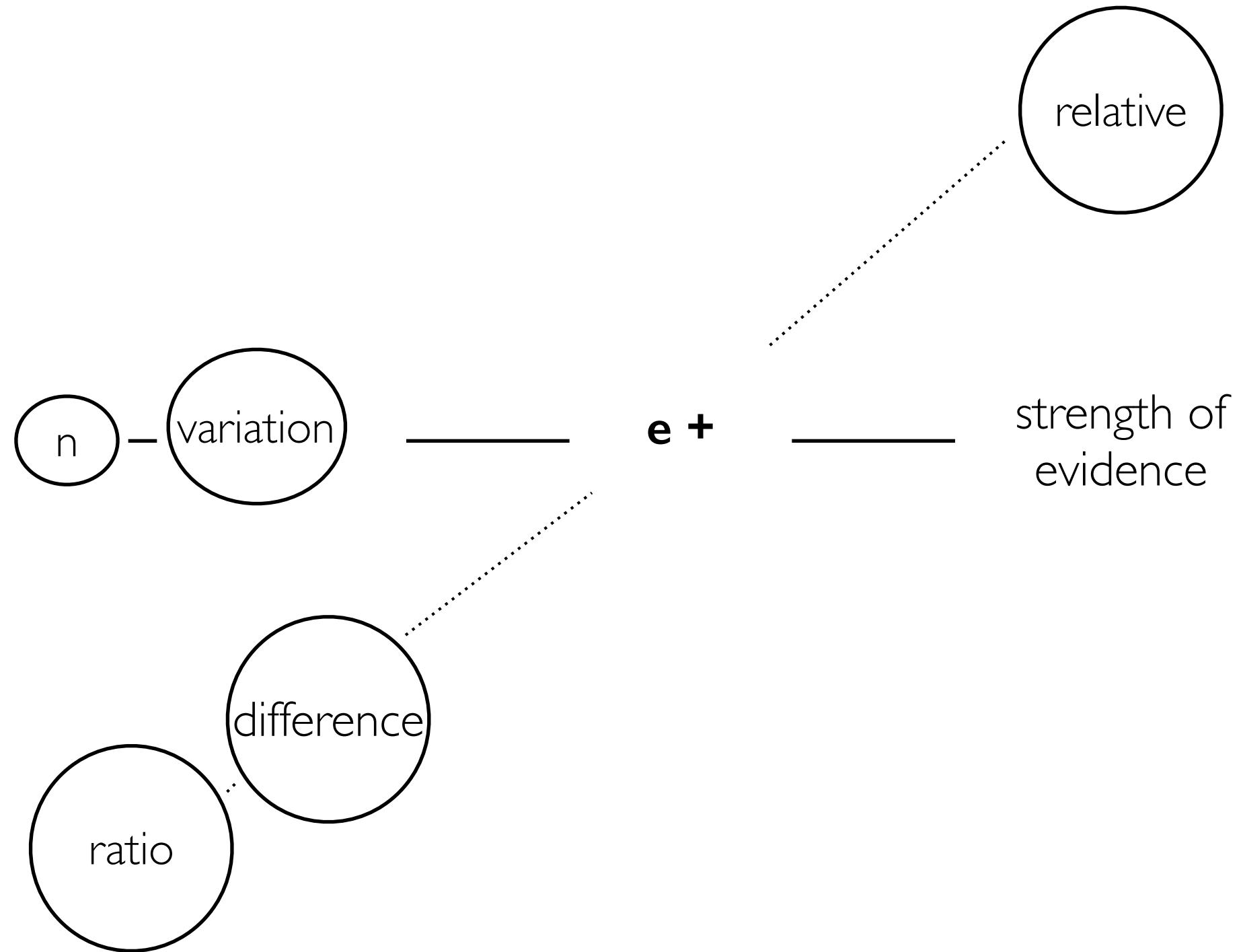
effect size

is a simple way of quantifying the difference between two groups  
i.e. treatment versus control

**e +**

effect size

is a quantitative measure of the strength of evidence



**e +**

\_\_\_\_\_

weighted difference of t - c

$\ln RR = \text{natural log}(t/c)$

$R_{ii} = (t - c)/(t + c)$

meta-analysis contrasts & combines evidence from different studies  
using effect size measures and appropriate statistics



progress in science synthesis

# review

integration  
vote-count

# synthesis

data-aggregation  
nceas  
summary  
combination

publications

# meta-analysis

meta-analysis

data-aggregation

summary

vote-count

review

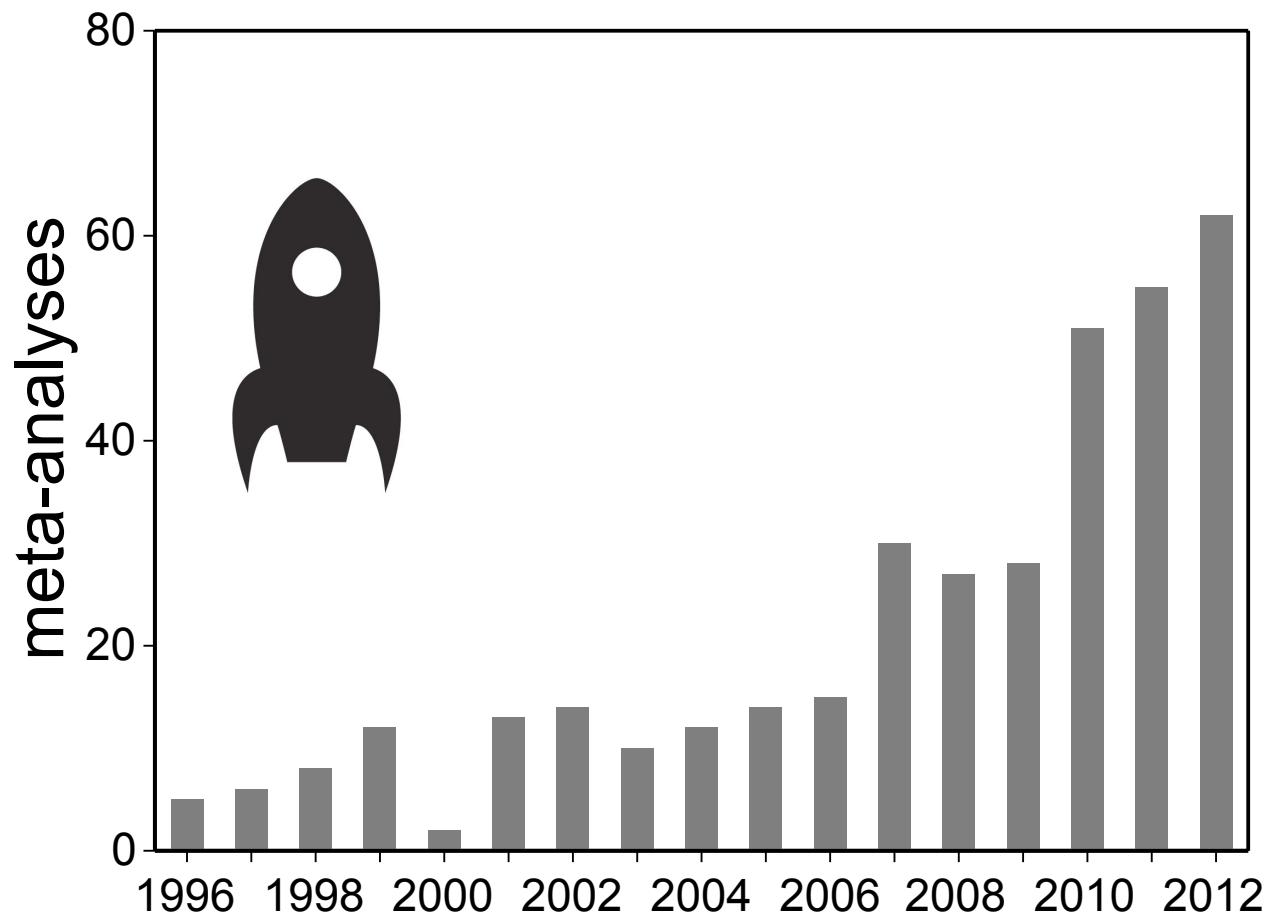
nceas

combination

citations

integration  
synthesis

exponential increases

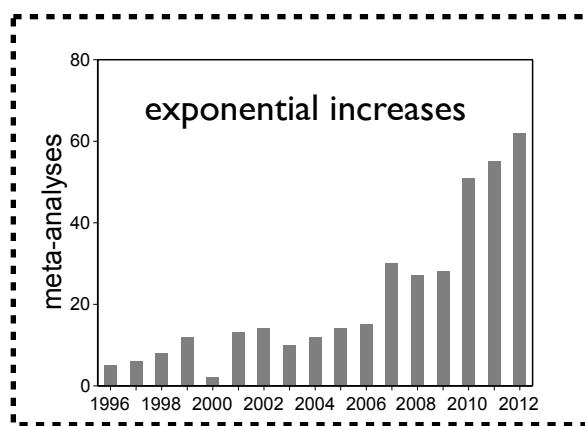


data sharing = key element

combine & mine disparate datasets  
develop novel insight tools

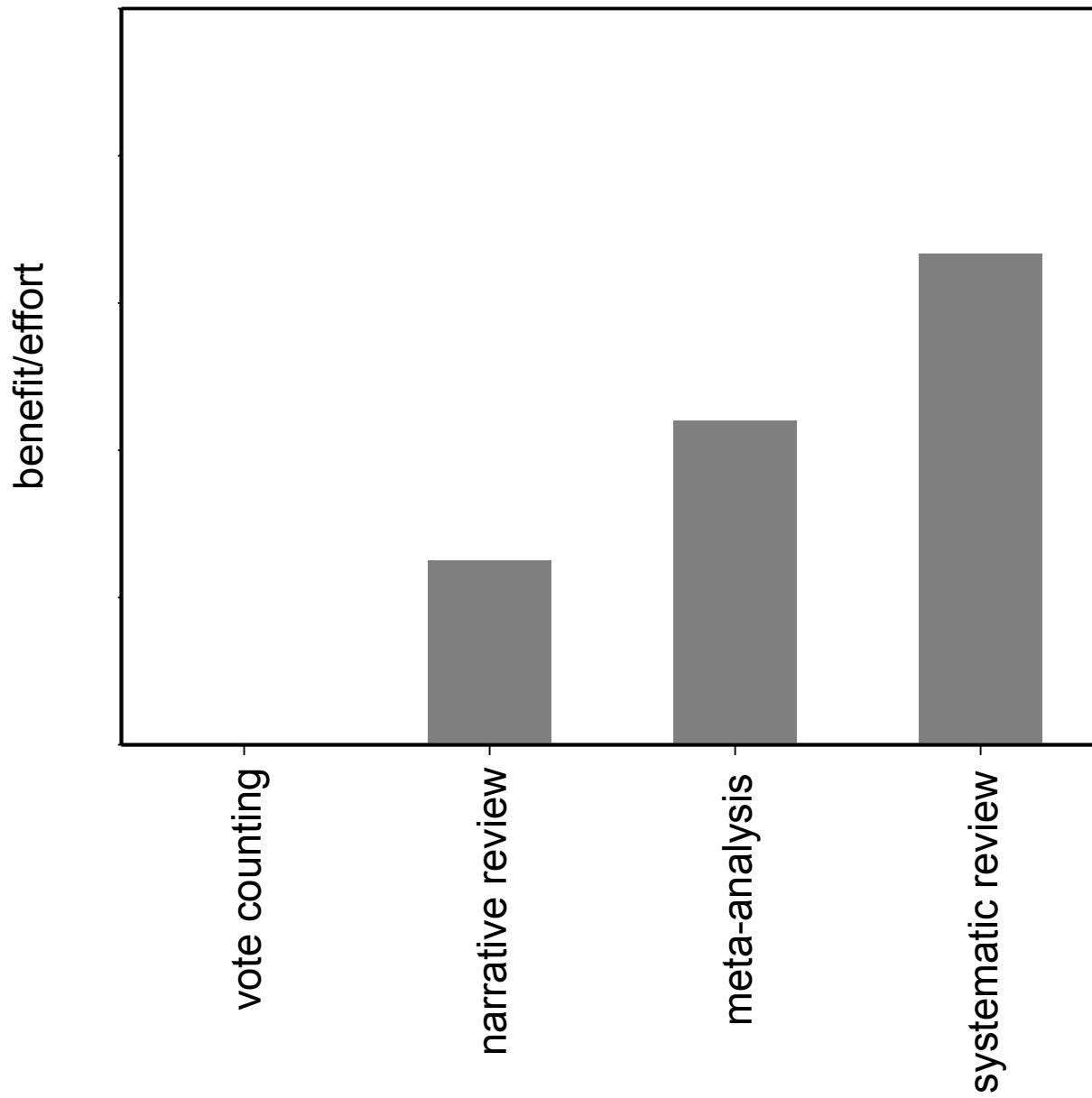
**data**

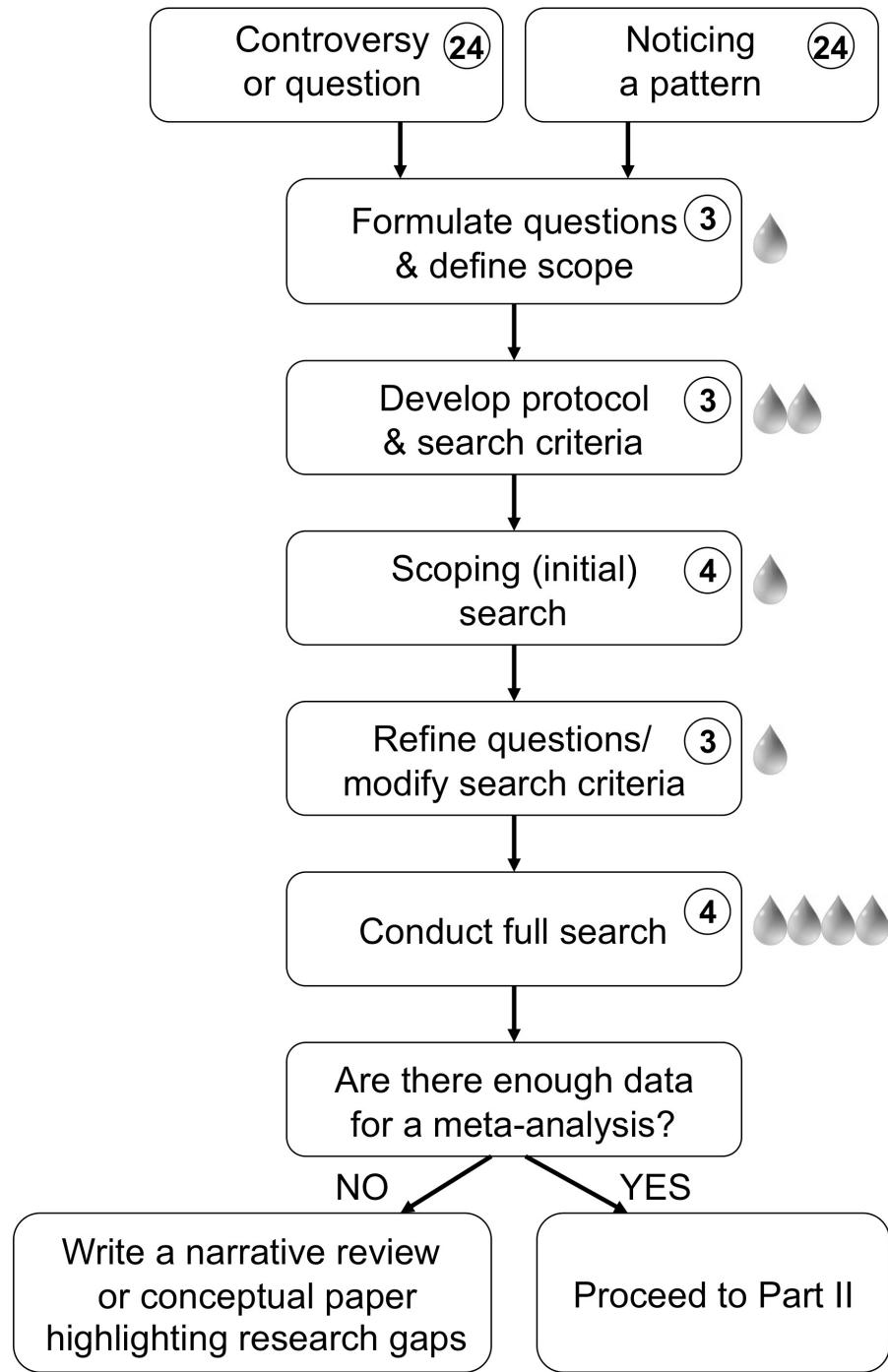
link to education & application

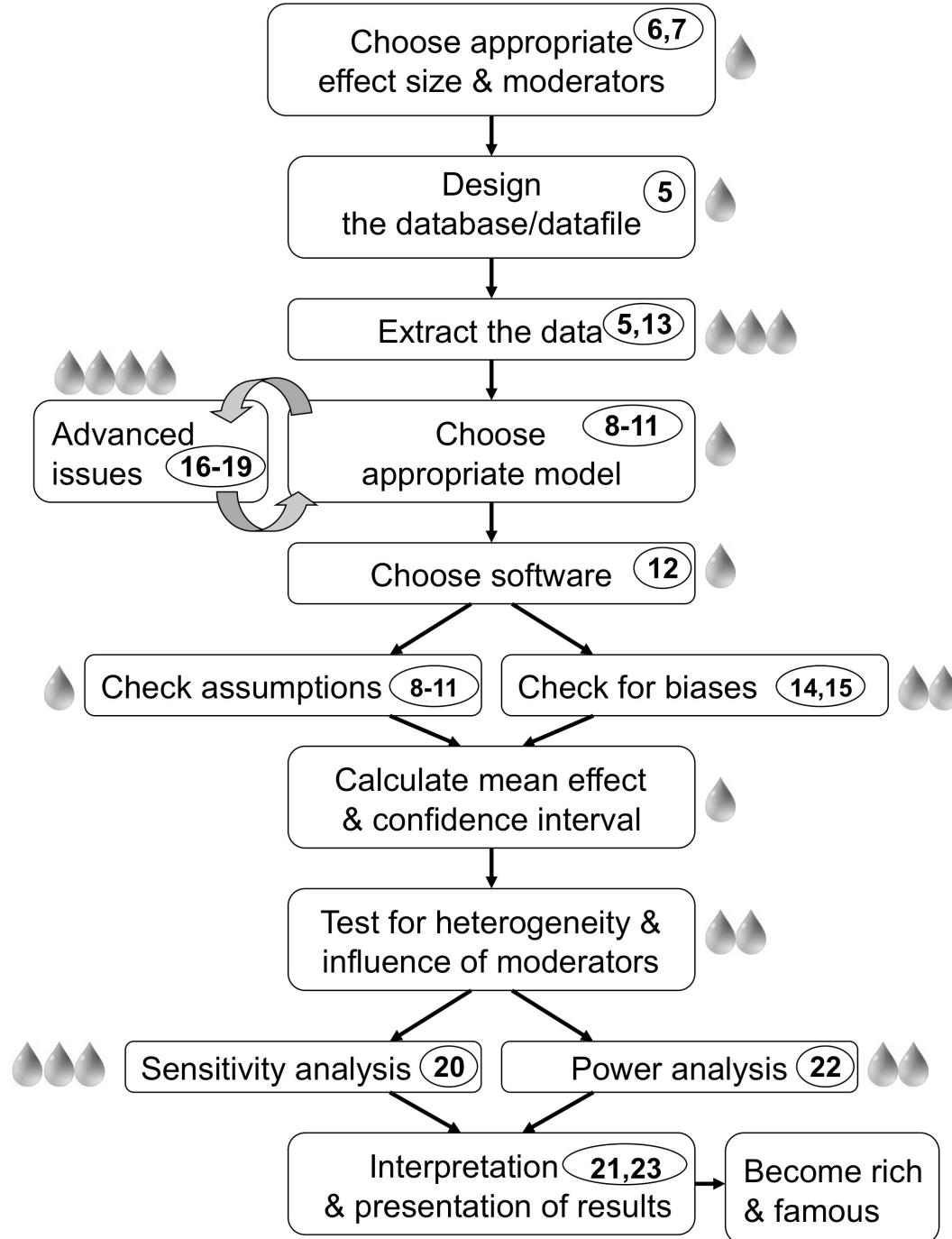


vocabulary standardization  
data aggregation  
systematic reviews

**tools**







we need to recognize that we are not conservation biologists trying to save other species. we are one emergence of life on this planet trying to save itself.

Allendorf

both sets of scientific synthesis tools can help us manage knowledge & inform evidence-based decisions

