Meta Analysis

Dr. K. W. Fu

Journalism and Media Studies Centre

The University of Hong Kong

Definition

- “Meta-analysis is a set of methods and statistical analyses for summarizing the findings of an existing empirical literature. As the name implies, it is a study of studies. It provides a way to do a quantitative literature review that involves cumulating effects across studies’”

Levine, Timothy R. and Craig R. Hullett. "Meta-Analysis." The International Encyclopedia of Communication. Donsbach, Wolfgang (ed). Blackwell Publishing, 2008. Blackwell Reference Online. 24 October 2011 <http://www.communicationencyclopedia.com/subscriber/tocnode?id=g9781405131995_chunk_g978140513199518_ss78-1>

Why Meta-analysis?

- Limitations of a single study
  - Statistical power issue
  - Sample size and resource issue
  - Methodological artifacts
  - Unknown confounders or isolated factors
- "Quantitative synthesis" of study effect size
- To identify the reasons why findings are inconsistent from study to study and theoretically important moderators

Meta-analysis

- Meta-analysis - statistical integration of separate studies
- Working with systematic review
- In contrast with “subjective” narrative review
- Transparent review process

Systematic Review and Meta Analysis

- "Systematic review" denotes any type of review that has been prepared using strategies to avoid bias and that which includes a material and methods section.
- Systematic reviews can include meta-analyses (the quantitative part)
- Top level of evidence (in evidence based science)

Applications (Political Science)

- Richard R. Lau, Lee Sigelman, Caroline Heldman and Paul Babbitt. The Effects of Negative Political Advertisements: A Meta-Analytic Assessment. *The American Political Science Review*. Vol. 93, No. 4 (Dec., 1999), pp. 851-875

"Negative political ads appear to be no more effective than positive ads and do not seem to have especially detrimental effects on the political system"

TABLE 2. Summary of Adjusted Parametric Results

	N of Studies	Total *N* of Subjects	Corrected for Sampling Error: Effect Size	Corrected for Sampling Error: Standard Error	Corrected for Attenuation Due to Measurement Error: Effect Size	Corrected for Attenuation Due to Measurement Error: Standard Error	Corrected for Sampling Error, Measurement Error, and Variation in Strength of IV: Effect Size	Corrected for Sampling Error, Measurement Error, and Variation in Strength of IV: Standard Error
Affect for Ad Itself	10	1,580	−.52	.44	−.61	.51	−.63	.63
Intended Effects								
Memory for ad	14	7,529	.88	.69	1.11	.79	.55	.49
Candidate-centered intended effects	35	14,458	−.14	.09	−.16	.11	−.15	.12
Unintended Effects								
Combined	22	45,948	.05*	.02	.07**	.05	.04	.05
Just turnout	17	44,644	.03	.07	.04	.08	.02	.09

Note: This analysis aggregates across multiple findings (within category) reported by any study. *$p < .05$, **$p < .01$.

Applications (Sociology)

- Robert L. Crain and Rita E. Mahard . The Effect of Research Methodology on Desegregation-Achievement Studies: A Meta-Analysis. *The American Journal of Sociology*. Vol. 88, No. 5 (Mar., 1983), pp. 839-854

"A meta-analysis of 323 samples of black students experiencing desegregation, derived from 93 research studies, finds two methodological factors correlated with the measured effect of desegregation on academic achievement."

TABLE 1

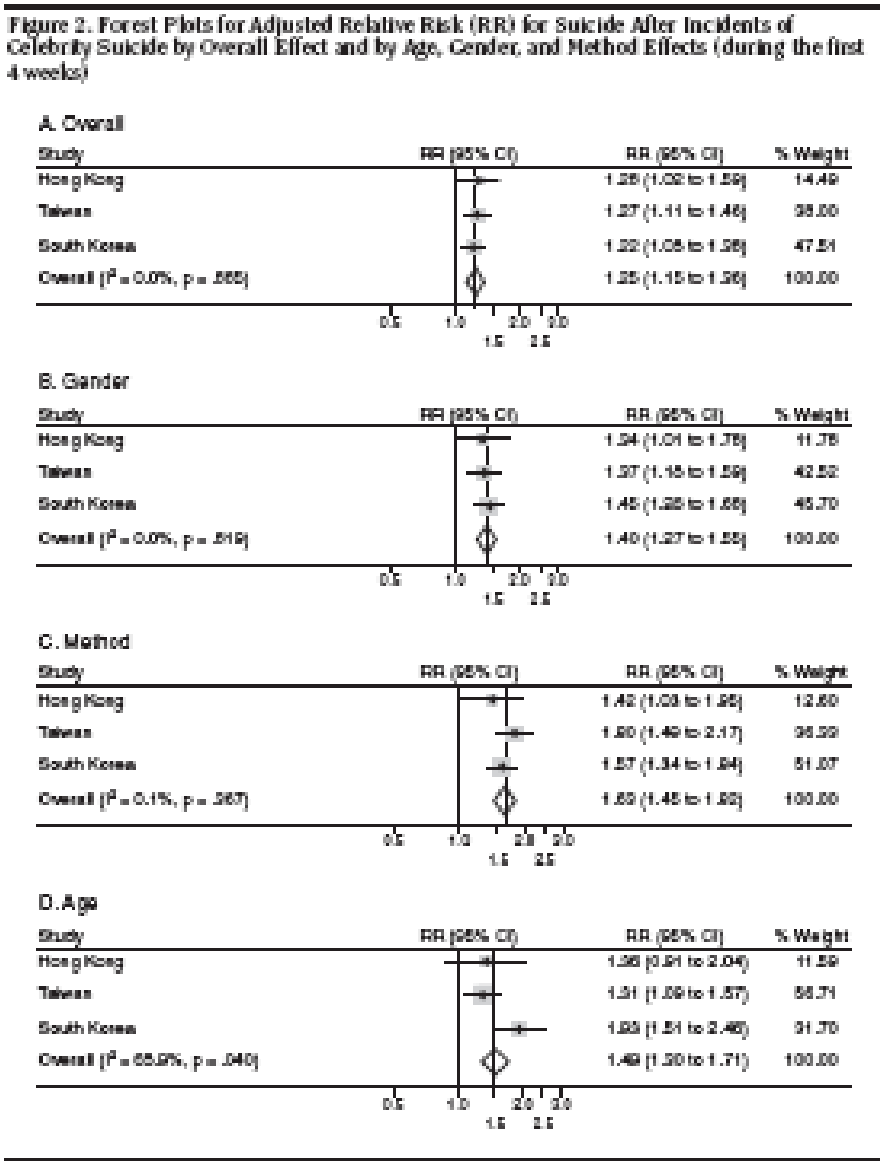
DIRECTION AND SIZE OF TREATMENT EFFECT, BY TYPE OF CONTROL GROUP

Design	Direction of Effect				Effect Size	
	+	0	—	*N*	d	*N*
Longitudinal, random	86	5	10	21	.235	15
Longitudinal, justified	48	39	13	23	.086	16
Longitudinal, nonrandom	57	16	27	118	.082	100
Cross-sectional	62	13	26	39	.130	34
Cohort	53	16	31	64	.084	53
White controls	33	8	58	12	.058	12
Norm controls	34	11	54	44	−.030	39
Total sample	54	16	30	321	.080	269

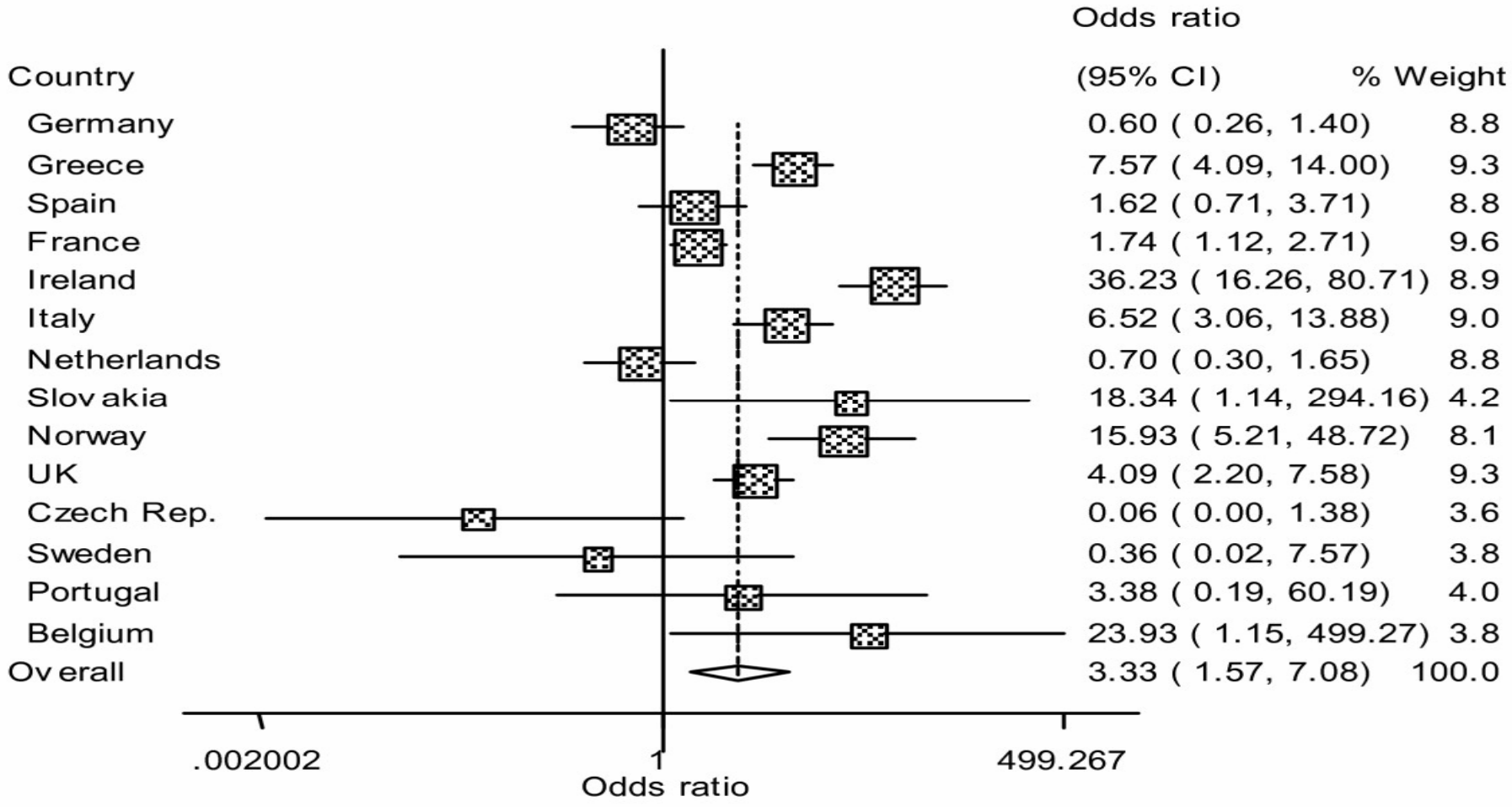
Applications (Behavioral Science)

- Fu, K.W., & Yip, P S. (2009). Estimating the risk for suicide following the suicide deaths of three Asian entertainment celebrities: A meta-analysis approach. *Journal of Clinical Psychiatry*, 70(6), 869-878.

- "The combined risks for suicide were found to be 1.43 (95% CI = 1.23 to 1.66), 1.29 (95% CI = 1.12 to 1.50), and 1.25 (95% CI = 1.08 to 1.45) in the first, second, and third week, respectively, after suicides of entertainment celebrities, while adjusting for secular trends, seasonality, economic situation, and temporal autocorrelation."



Forest Plot


Odds ratio
Country
(95% CI)
% Weight
Germany
0.60 (0.26, 1.40) 8.8
Greece
7.57 (4.09, 14.00) 9.3
Spain
1.62 (0.71, 3.71) 8.8
France
1.74 (1.12, 2.71) 9.6
Ireland
36.23 (16.26, 80.71) 8.9
Italy
6.52 (3.06, 13.88) 9.0
Netherlands
0.70 (0.30, 1.65) 8.8
Slovakia
18.34 (1.14, 294.16) 4.2
Norway
15.93 (5.21, 48.72) 8.1
UK
4.09 (2.20, 7.58) 9.3
Czech Rep.
0.06 (0.00, 1.38) 3.6
Sweden
0.36 (0.02, 7.57) 3.8
Portugal
3.38 (0.19, 60.19) 4.0
Belgium
23.93 (1.15, 499.27) 3.8
Overall
3.33 (1.57, 7.08) 100.0
.002002
1
499.267
Odds ratio

Myths about Systematic Reviews and Meta-Analysis (Littell, 2008)

Myth	Fact
Meta-analysis comes from biomedical research and requires a medical perspective.	Meta-analysis was initially developed in the social and behavioral sciences
Systematic reviews and meta-analyses are appropriate only for studies of treatment effects.	These methods are appropriate for many kinds of research questions: correlations, prevalence rates, accuracy of diagnostic tests etc
Systematic reviews can (or should) include only randomized controlled trials (RCTs).	Many systematic reviews include nonrandomized designs, such as case-control studies, interrupted time-series designs, prospective design, observational studies.
Meta-analysis requires many studies.	Meta-analysis can be performed with two studies.
Meta-analysis requires large studies.	Sample size in the original studies is not an appropriate inclusion criterion. There are tests and corrections for small-sample bias.
Meta-analysis can overcome problems with quality (validity) in original studies.	Study qualities can be examined, analyses can detect which study qualities may matter, and results of higher-quality studies can be emphasized.

Comparisons between Systematic Review & Survey Research (Littell, 2008)

Step	Systematic Review	Survey Research
Topic formulation	Central questions, hypotheses, objectives	Central questions, hypotheses, objectives
Study design	Protocol development	Protocol development
	Specify problems/conditions, populations, settings, interventions, and outcomes of interest	Specify key constructs, information needs
	Specify study inclusion and exclusion criteria	Specify sample characteristics
Sampling	Develop a sampling plan	Develop a sampling plan
	Sampling unit is the study	Sampling unit may be the individual, household, or group
	Consider universe of all potentially relevant studies	Identify sampling frame (all relevant sampling units)
	Obtain studies	Sample units

Comparisons between Systematic Review & Survey Research (Littell, 2008)

Step	Systematic Review	Survey Research
Data collection	Extracted from studies onto standardized forms	Collected from individuals via surveys or interviews
Data analysis	Descriptive data (examine study qualities, samples, and intervention characteristics; compute effect sizes)	Descriptive data (examine qualitative and categorical data, frequencies and distributions on continuous variables)
	Pool effect sizes and assess heterogeneity (meta-analysis)	Measures of central tendency and variability
	Cumulative meta-analysis, subgroup and moderator analysis, sensitivity analysis, analysis of publication and sample bias	Bivariate and exploratory analyses
	Meta-regression	Multivariate analyses
Reporting	Descriptive tables and graphs	Descriptive tables and graphs
	Interpretation and discussion	Interpretation and discussion
	Implications for policy, practice, and research	Implications for policy, practice, and research

Steps in Performing a Meta-Analysis

Blettner & Schlattmann, (2005) Meta-Analysis in Epidemiology. Springer Berlin Heidelberg

Step 1. Define a clear and focused topic for the review

- A clear protocol, research hypothesis & objectives
- Exact definition of the interest, the risk factors and the potential confounding variables
- The protocol should also include details on the steps that are described below, including specification of techniques for location of the studies, the statistical analysis and the proposed publications.

Step 2. Establish inclusion and exclusion

- Define in advance which studies should be included into the meta-analysis.
- These criteria may include restrictions on the publication year, on the design of the investigation
- Quality criteria to evaluate each study
- A rule for the inclusion or exclusion of papers with repeated publication of the data is required.

Step 3. Locate all studies that are relevant to the topic

- Search the universe of relevant studies on the topic that
- meet the inclusion criteria (published and unpublished)
- Electronic database search and manual checks of the reference lists of retrieved papers, monographs, books and if possible by personal communications with researchers in the field.
- Avoid publication bias or selection bias

Step 4. Abstract information from the publications

- Most time consuming part
- Some key parameters: relative risk, odds ratio, standard error, sample size, treatment of confounders and other characteristics of the study design and quality of the study.
- Also important for subgroup analyses or for a sensitivity analysis.
- An abstract form has to be created before abstracting data.
- It may not always be possible to abstract the required estimates directly
- Blinding & Inter-rater difference

Step 5. Descriptive analysis

- Summarizing the results, including tabulation of relevant elements of each study, such as sample size, data collection procedures, confounder variables, means of statistical analysis, study design, publication year, performing year, geographical setting etc.

Step 6. Statistical analysis

- This includes the analysis of the heterogeneity of the study-specific effects, the calculation of a pooled estimate and the confidence interval as well as a sensitivity analysis (meta-regression).

Step 7. Interpretation of the results

- NOT ONLY the pooled estimate
- Potential biases, say publication bias (funnel plot), sources of data and magnitude of different biases should be taken into account when interpreting the results.
- Pay more attention to the investigation of the heterogeneity between studies

Step 8. Publication

- The QUOROM statement – a checklist and flowchart
- Stroup et al. (2000) - for reporting meta-analyses

D Moher, DJ Cook, S Eastwood, I Olkin, D Rennie, DF Stroup and QUORUM Group, Improving the quality of reports of meta-analyses of randomised controlled trials: the QUORUM statement, Lancet 354 (1999), pp. 1896–1900

Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, Rennie D, Moher D, Becker BJ, Sipe TA, Thacker SB (2000) Meta-analysis of observational studies in epidemiology: A proposal for reporting. JAMA 283:2008–2012

Fixed effects model vs. Random effects model

- Fixed effects model vs. random effects model
  - Fixed effect (FE) models are based on the assumption that all of the studies come from the same population and produce estimates of one true ES. This assumes that "all factors which could influence the effect size are the same" in all studies
  - Random effects (RE) models are based on the assumption that the true effect might vary across samples and studies. The effect might be larger or smaller, depending on the age, health, or wealth of participants, the length and intensity of treatment, study design artifacts, and so forth

Fixed effects model vs. Random effects model

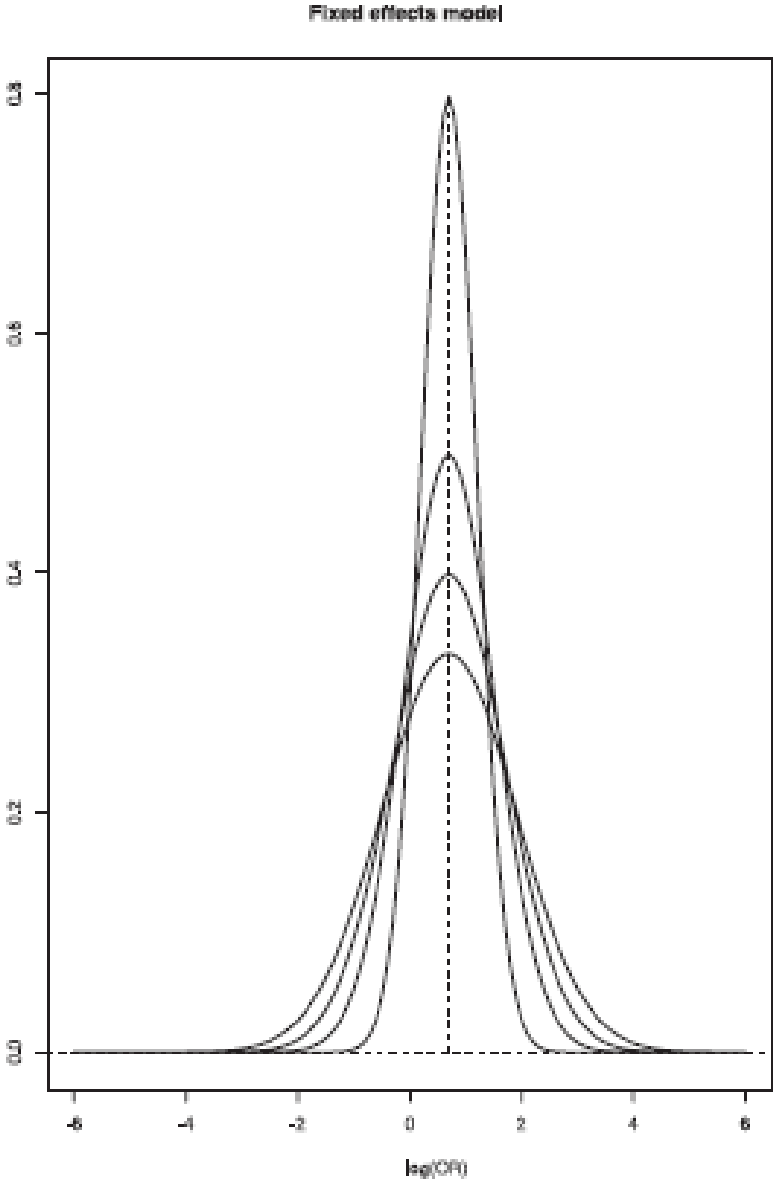


Figure 7.5. Fixed effects model: Common effect with different study variances

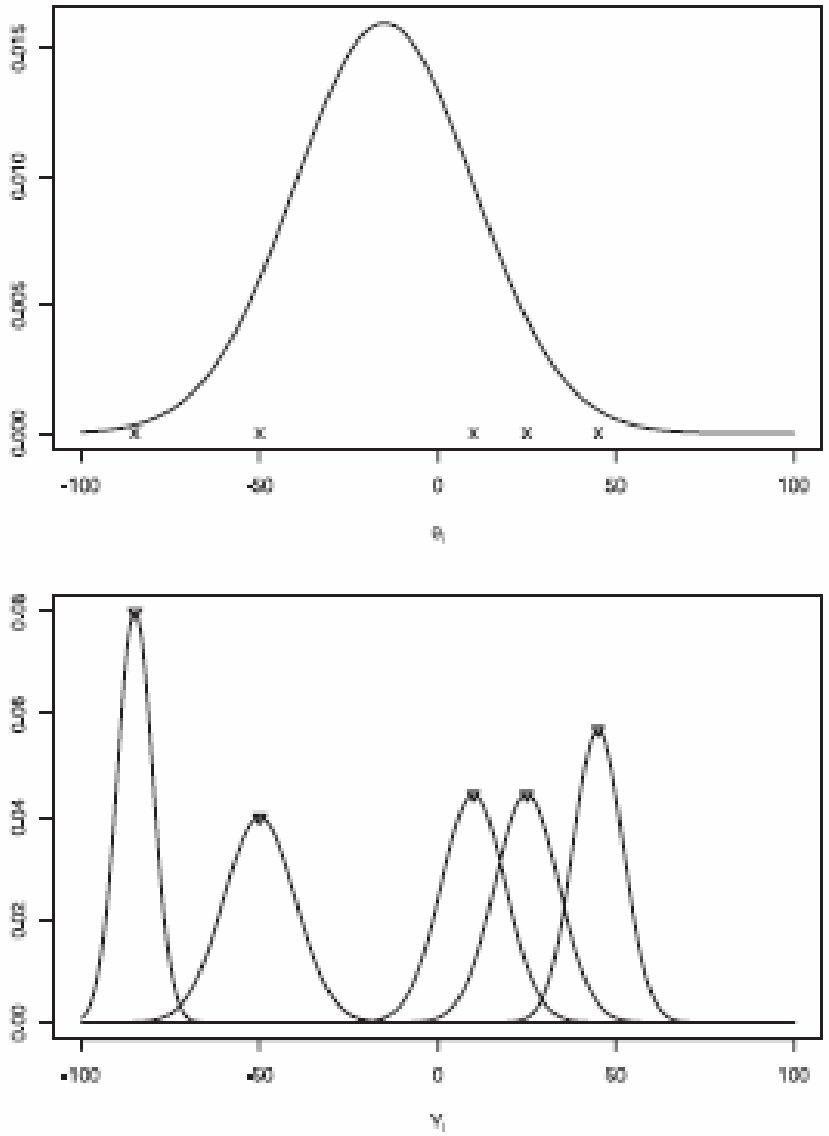


Figure 7.6. Random effects model: Variable effects drawn from a population of study effects

Heterogeneity

- Variation in study outcomes between studies
- Combinable or not combinable, that is the question
- A main task in each review or meta-analysis
- Several statistical tests are available
- Most common heterogeneity test, I^2

Publication bias

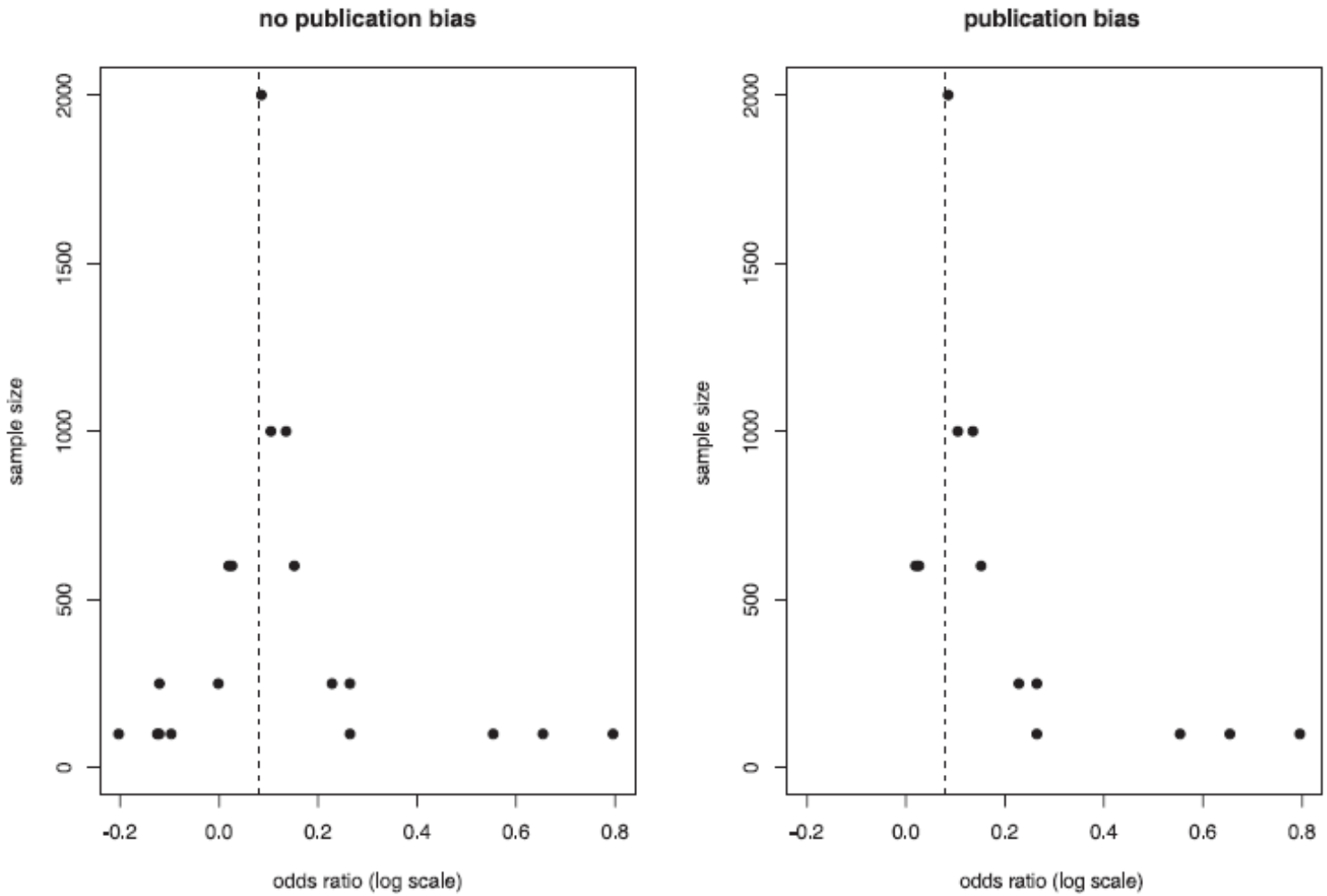


Figure 7.2. Examples of funnel plots based on simulated data with (*right figure*) and without publication bias present (*left figure*). The *dotted line* shows the true effect

Meta-regression

- Meta-regression is an important method for investigating heterogeneity
- To identify sources of heterogeneity by inclusion of known covariates
- Weighted least squares regression or mixed effects model

Criticisms

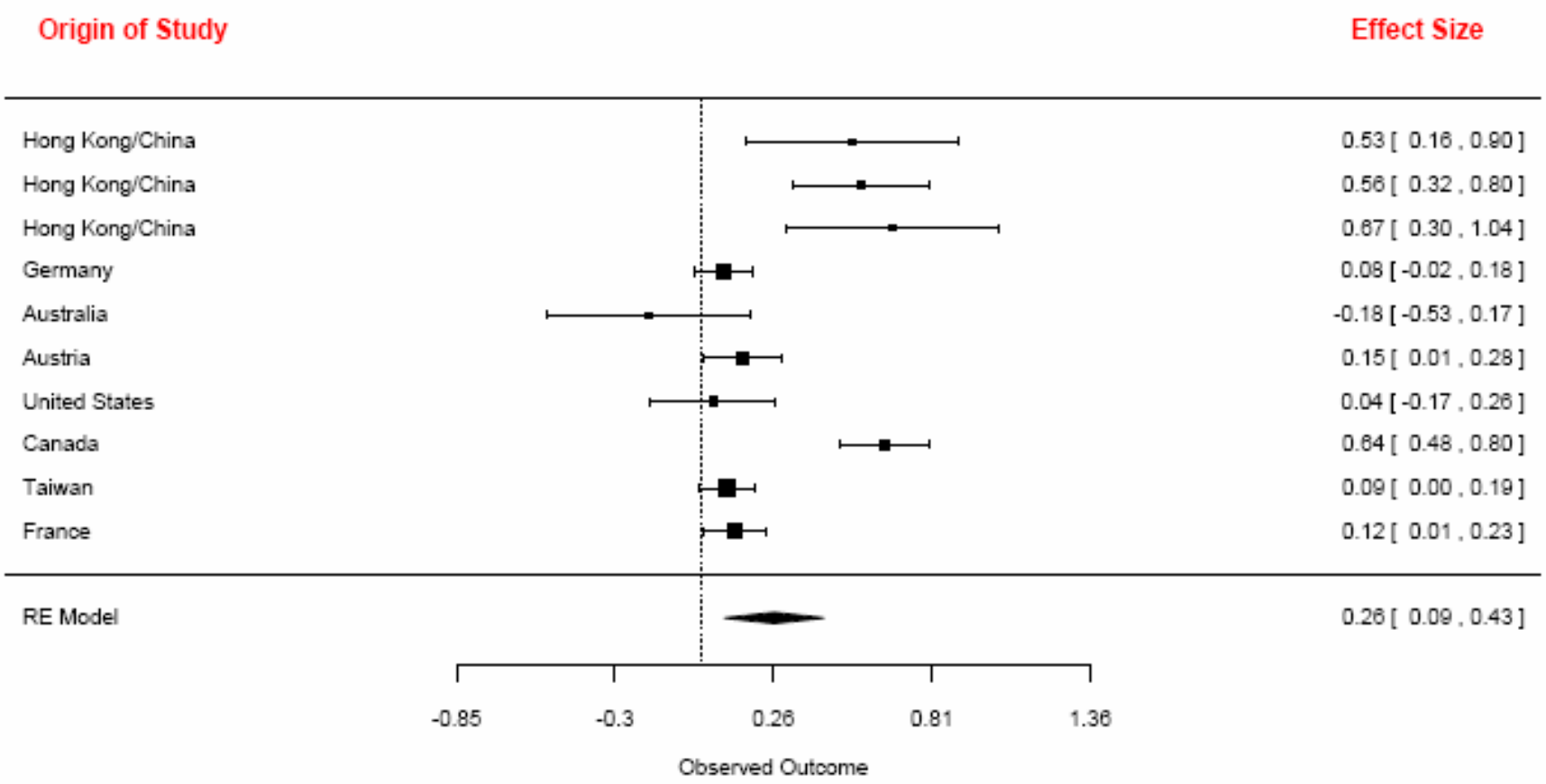
- Really combinable?
- Publication bias
- Problems with the implementation of meta-analyses (Garbage In, Garbage Out)
- Disagreement between meta-analyses
- Disagreement between meta-analysis and the subsequent large trials
- Study-level analysis vs. individual-level analysis

Example

Changes in suicide rates following media reports on celebrity suicide: a meta-analysis

Eligible studies (listed in alphabetical order)	Year of Publication	Region of Study	No of reported celebrity suicides	Characteristics of suicides	Type of celebrity	Population Size (million)[1]
Fu and Yip	2009	Hong Kong	1	Mr. Leslie Cheung	National entertainment elite	6.77
Fu and Yip	2009	Taiwan	1	Mr. Min-Jan Nee	National entertainment elite	22.69
Fu and Yip	2009	South Korea	1	Ms. Eun-ju Lee	National entertainment elite	48.01
Jonas	1992	Germany	32	Record from German magazines, official record, and human inspection	Mixed sample	9.09
Martin and Koo	1997	Australia	1	Kurt Cobain	Foreign or less known entertainer	2.72
Niederkrotenthaler et al.	2009	Austria	16	"A celebrity" being present in the media	Mixed sample	8.09
Stack	1987	United States	38	Appeared in New York Times	Mixed sample	192.80
Tousignant et al.	2005	Canada	1	Gaetan Girouard	National entertainment elite	7.34
Chen et al.	2010	Taiwan	1	Ms. Ivy Li,	Foreign or less known entertainer	22.9
Queinec et al. [24]	2011	France	6	Celebrity's name appeared at least 100,000 times in pages indexed in French of a search engine.	Mixed sample	57.3

Changes in suicide rates following media reports on celebrity suicide: a meta-analysis



Heterogeneity test showed significant between-study variation (I2 =91%; Q=66.8, p<0.0001)

Results of Mixed-Effects Meta-Regression Model

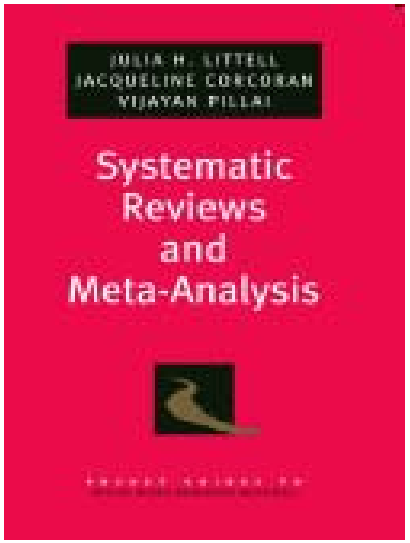
	Effect Estimate (95% CI)	p-value
Interpret	0.09 (-0.06 to 0.24)	0.14
National entertainment elite[1]	0.55 (0.37 to 0.72)	0.002**
Foreign or less known entertainer[1]	0.06 (-0.15 to 0.27)	0.43
Region of Study: Asia[2]	-0.06 (-0.20 to 0.08)	0.25
Region of Study: Australia[2]	-0.28 (-0.55 to -0.02)	0.04**
Region of Study: Europe[2]	0.04 (-0.10 to 0.18)	0.47
Year of Publication 1980-1999[3]	-0.05 (-0.13 to 0.03)	0.13

Note: '***' $p<0.01$ '**' $p<0.05$ '*' $p<0.10$
Test for Residual Heterogeneity (df = 3) = 0.3971, p = 0.9408
[1] Reference group is mixed samples.
[2] Reference group is Region of Study: North America
[3] Reference group is Year of Publication 2000-2009

Live Demonstration Using R

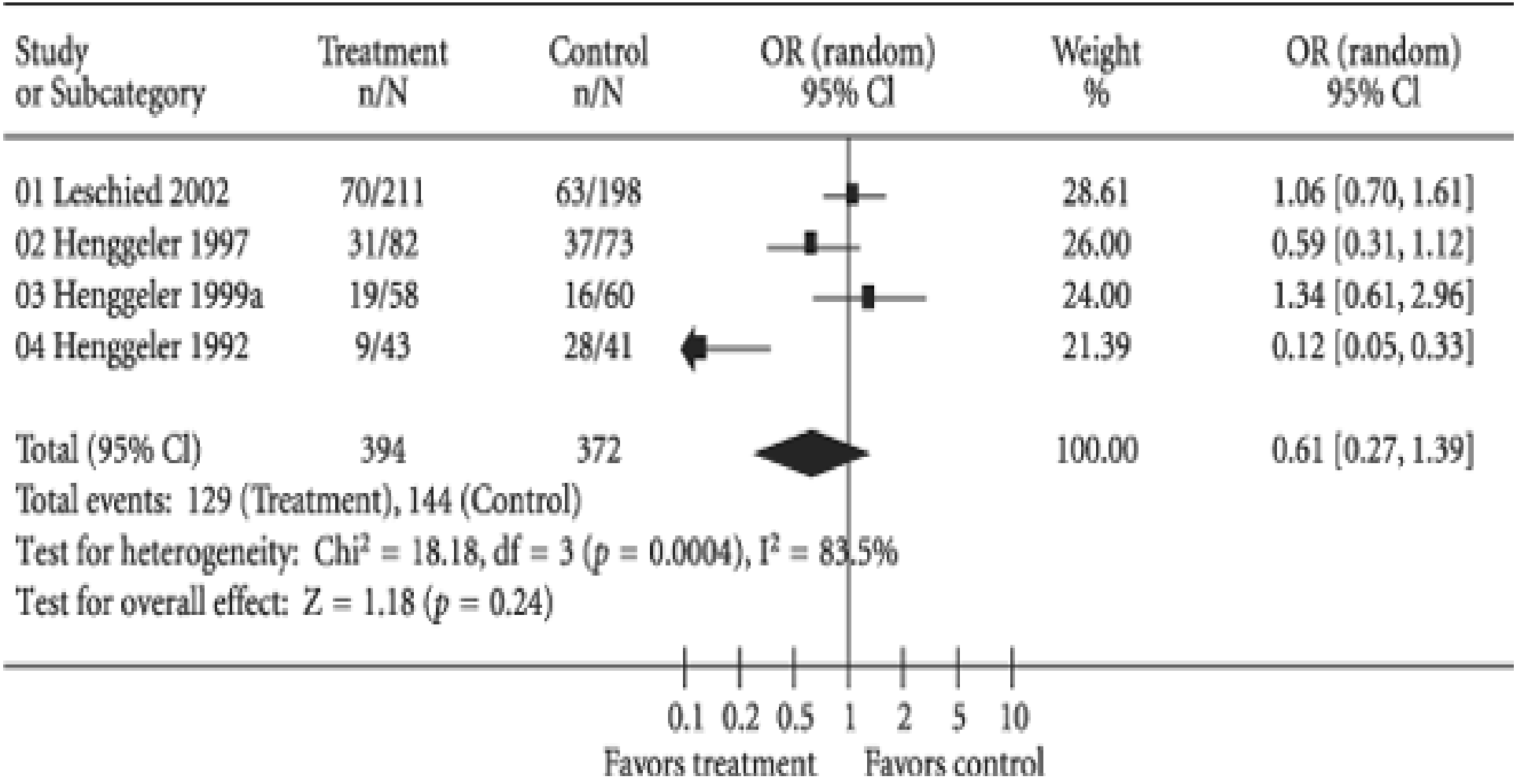
Reference

- AUTHOR Littell, Julia H.
- TITLE Systematic reviews and meta-analysis [electronic resource] / Julia H. Littell, Jacqueline Corcoran, Vijayan Pillai.
- IMPRINT Oxford ; New York : Oxford University Press, 2008.
- Permanent URL for this record=> http://library.hku.hk/record=b4164418



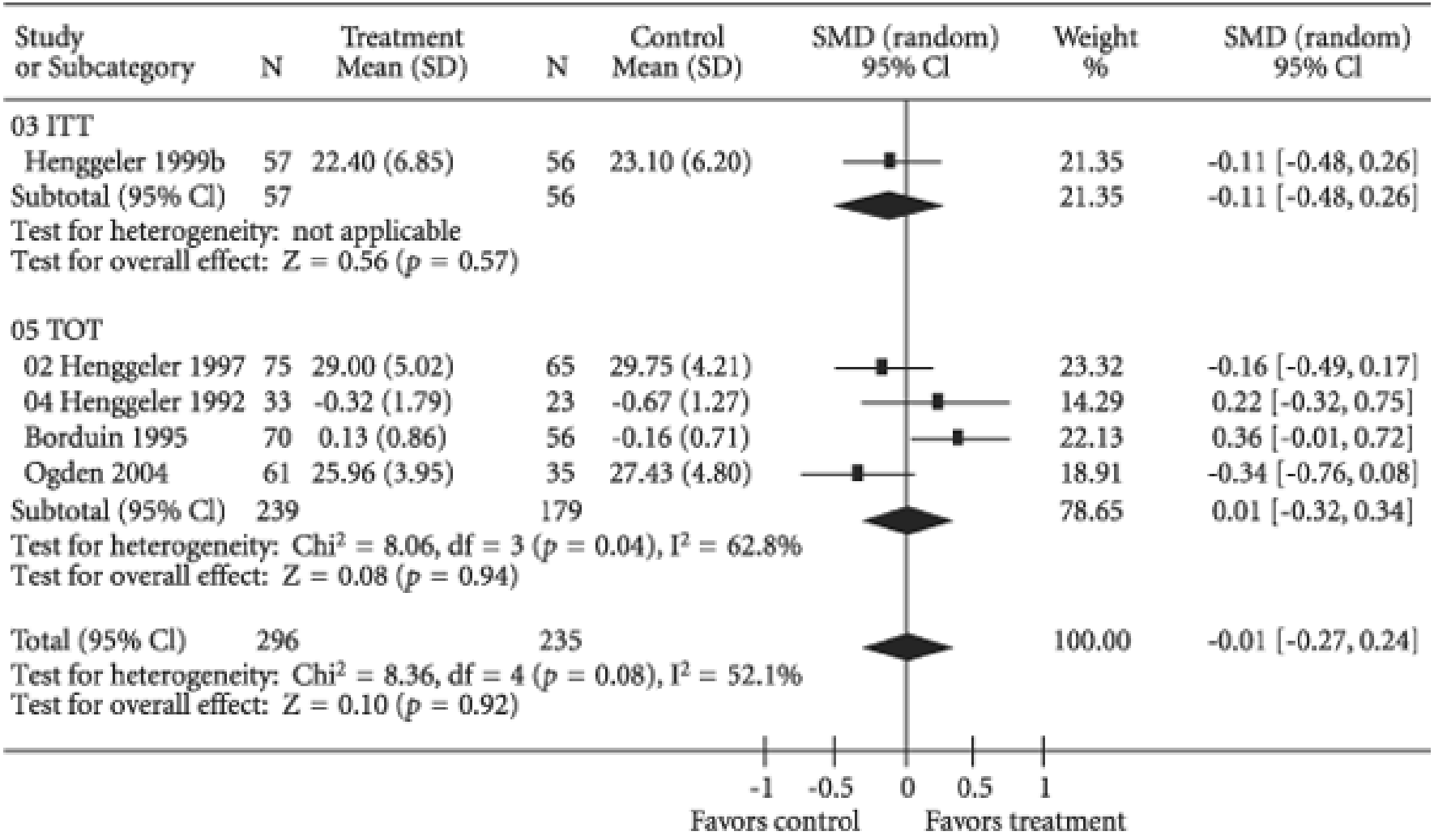
- Download R
  - http://cran.r-project.org/
- R code for meta analysis
  - http://sites.google.com/site/fukingwa/home/presentations

For Odds ratios



Source: Littell, Popa, & Forsythe, 2005; Julia H. Littell, Jacqueline Corcoran, Vijayan Pillai. (2008) Systematic reviews and meta-analysis. Oxford ; New York : Oxford University Press

For Standard Mean Difference



Source: Littell, Popa, & Forsythe, 2005; Julia H. Littell, Jacqueline Corcoran, Vijayan Pillai. (2008) Systematic reviews and meta-analysis. Oxford ; New York : Oxford University Press

R Codes

```
library("meta")

%% For Odds Ratios

example <-
        data.frame(Study_name=c("Les2002","Hen1997","Hen1999a","Hen1992"),Tr_n=c(70,31,19,9),Tr_N=c(211,82,58,43),Co_n=c(
        63,37,16,28),Co_N=c(198,73,60,41))

example

example_OR <- metabin(Tr_n,Tr_N,Co_n,Co_N,data=example,studlab=Study_name,sm="OR")

example_OR

summary(example_OR)

forest.meta(example_OR)

funnel(example_OR)

%% For SMD

example1 <- data.frame(Study_name=c("Hen1997","Hen1992","Bor1995","Ogd2004"),Tr_n=c(75,33,70,61),Tr_mean=c(29.0,-
        0.32,0.13,25.96),Tr_sd=c(5.02,1.79,0.86,3.95),Co_n=c(65,23,56,35),Co_mean=c(29.75,-0.67,-
        0.16,27.43),Co_sd=c(4.21,1.27,0.71,4.8))

example1

example_con <- metacont(Tr_n,Tr_mean,Tr_sd,Co_n,Co_mean,Co_sd,data=example1,studlab=Study_name,sm="SMD")

example_con

summary(example_con)

forest.meta(example_con)

funnel(example_con)
```

Steps in the Systematic Review Process (Littell, 2008)

- Develop a set of clearly formulated objectives and specific, answerable research questions or hypotheses. This is best done in consultation with people who are likely to use results of the review (practitioners, policy makers, and consumers).
- Form a review team that includes people with the diverse skills necessary (including substantive, methodological, and technical expertise).
- Create explicit inclusion and exclusion criteria that specify the problems, conditions, populations, interventions, settings, comparisons, outcomes, and study designs that will and will not be included in the review.
- Develop a written protocol that details in advance the procedures and methods to be used.
- In collaboration with information specialists, identify and implement a comprehensive and reproducible strategy to identify all relevant studies. This includes strategies to find unpublished studies.
- Screen titles and abstracts to identify potentially relevant studies.
- Retrieve published and unpublished reports on potentially relevant studies.
- Determine whether each study meets the review's eligibility criteria. Two reviewers judge each study, resolve disagreements (sometimes with a third reviewer), and document their decisions.