# Applying Evidence-Based Practice with Meta-Analysis

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### A little bit background about me (1)

- PhD: Quantitative psychology, the Chinese University of Hong Kong
- Associate Professor:
  - Department of Psychology, National University of Singapore (NUS)
  - Department of Management & Organisation (courtesy appointment), NUS
- Research areas: Quantitative methods
  - Structural equation modeling, meta-analysis, multilevel model, analysis of missing data, longitudinal data analysis, analysis of non-normal data, etc.

### A little bit background about me (2)

- Associate editors:
  - Research Synthesis Methods
  - Neuropsychology Review
  - Frontiers in Psychology (Quantitative Psychology and Measurement)
- Editorial boards:
  - Psychological Methods
  - Psychological Bulletin
  - Journal of Management (Methods task force)
  - Health Psychology Review (Research methods and data analysis)

- Introduce how systematic review and meta-analysis can be used in evidence-based practice.
- Introduce what meta-analysis is.
- Note: We cannot cover how to conduct the analyses in only 2 hours!

- Practices in psychology, e.g., interventions, teaching methods, approaches, should be based on the best scientific evidence:<sup>1</sup>
- There are various types of evidence, e.g.,
  - Clinical observation
  - Qualitative research
  - Single-case experimental
  - Studies of interventions
  - RCTs
  - Meta-analysis

<sup>&</sup>lt;sup>1</sup>APA Presidential Task Force on Evidence-Based Practice. (2006). Evidence-based practice in psychology. *The American Psychologist*, *61*(4), 271-285.

#### What is the Hierarchy of Evidence?

Some types of evidence are stronger than others.<sup>2</sup>



<sup>2</sup>Guyatt, G. H., Sackett, D. L., Sinclair, J. C., Hayward, R., Cook, D. J., Cook, R. J., & Wilson, M. (1995). Users' Guides to the Medical Literature: IX. A Method for Grading Health Care Recommendations. *JAMA*, *274*(22), 1800-1804.

## What are the roles of systematic review and meta-analysis in evidence-based practice/research?

- Systematic review and meta-analysis can be used to summarize the best evidence in the literature.
- Some researchers even argue that systematic review should be done before conducting any new studies.<sup>3</sup>

<sup>&</sup>lt;sup>3</sup>Lund, H., Brunnhuber, K., Juhl, C., Robinson, K., Leenaars, M., Dorch, B. F., & Chalmers, I. (2016). Towards evidence based research. *BMJ*, *355*, i5440.

### Cochrane Cochrane Collaboration facilitates evidence-based research in health interventions faced by health professionals, patients, and policymakers (medical research). Campbell CollaborationCampbell Collaboration facilities evidence-based research about the effects of interventions in

the social, behavioral, and educational areas.

- A systematic review aims to provide a comprehensive literature search with pre-defined eligibility criteria.
- It focuses on minimizing bias in a literature review so that the literature search is replicable.

- A meta-analysis statistically combines the effect sizes and models the effect sizes with study characteristics.
- It has a few goals:
  - Draw general conclusions on a particular topic.
  - Test the homogeneity (consistency) of the findings.
  - Account for the heterogeneity of effect sizes.
  - Estimate an average effect size.
  - Test potential moderators if the studies are heterogeneous.

<sup>&</sup>lt;sup>4</sup>Cheung, M. W.-L., & Vijayakumar, R. (2016). A guide to conducting a meta-analysis. *Neuropsychology Review*, *26*(2), 121-128.

## What are the differences between a systematic review and meta-analysis?

- Researchers usually conduct a meta-analysis after the systematic review.
- A systematic review focuses on the process of identifying the studies.
- A meta-analysis provides a statistical method to combine the data.
- There are rare cases that researchers choose not to do a meta-analysis after a systematic review, e.g., the studies are so different and incompatible with each other.

- Are there enough primary studies for the meta-analysis?
  - If there are not enough studies, the field may not be mature for a meta-analysis.
- How important and pressing is the topic?
  - If the topic is critical to human lives and the society, researchers may still want to conduct a meta-analysis even though there are not too many primary studies.

- Effect size is a scale-free measure of the strength of the relationship.<sup>5</sup>
- Common effect sizes are correlation coefficient, raw and standardized mean difference, and odds ratio.
- Effect size is less sensitive to the sample size.
- If the effect sizes are not available from some of the studies, these studies may have to be excluded from the meta-analysis.

<sup>&</sup>lt;sup>5</sup>Cheung, M. W.-L., Ho, R. C. M., Lim, Y., & Mak, A. (2012). Conducting a meta-analysis: Basics and good practices. *International Journal of Rheumatic Diseases*, 15(2), 129-135.

- There are two basic models for meta-analysis.<sup>6</sup>
- They are based on different assumptions.
- Findings are generalized to specific conditions according to the models.

<sup>&</sup>lt;sup>6</sup>Cheung, M. W.-L. (2015). *Meta-analysis: A structural equation modeling approach*. Chichester, West Sussex: John Wiley & Sons, Inc.

- Conceptual issues:
  - Studies are direct replicates of each other;
  - Findings can only be generalized to studies with the same study characteristics;
  - Homogeneity of effect sizes may or may not be assumed.

- Conceptual issues:
  - Studies are randomly sampled from a pool of studies;
  - Findings can be generalized to other studies that are not included in the meta-analysis.
- Statistical issues:
  - Each study may have its own population or *true* effect size;
  - The variance of the *true* effect size can be estimated;
  - Differences in the observed effect sizes are due to both population heterogeneity and sampling errors.

#### Fixed- vs. random-effects models



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#### Forest plots: Homogeneous vs. heterogeneous effects

#### Homogeneous effects

#### Heterogeneous effects



- When there is excessive heterogeneity, we may want to explore why some studies have larger/smaller effects using study characteristics as moderators.
- It is similar to a regression analysis.

- What is the relationship of health local of control (HLOC) with specific health behaviors and global health appraisal?<sup>7</sup>
  - HLOC refers to people's attribution of their own health to personal or environmental factors: Internality dimension (I), Powerful others dimension (P), and Chance dimension (C).
  - Specific health behaviors: Exercise, diet, smoking, and alcohol consumption.
  - Global health appraisal: Mental Quality of Life (MQOL), Physical Quality of Life (PQOL), Depression, and Anxiety.

<sup>7</sup>Cheng, C., Cheung, M. W.-L., & Lo, B. C. Y. (2016). Relationship of health locus of control with specific health behaviours and global health appraisal: a meta-analysis and effects of moderators. *Health Psychology Review*, *10*(4), 460&477.

#### Flow chart for the systamtic review

• There is a total of 144 studies in the meta-analysis.



#### Results for the specific heavior behaviors

- All the associations are weak to moderate:
  - I-HLOC is related to exercise (r = .10) and diet (r = .08).
  - P-HLOC is related to alcohol consumption (r = -.05).
  - C-HLOC is related to diet (r = -.07) and smoking (r = .08).

	Exercise			Diet			Smoking			Alcohol consumption		
	I-HLOC	P-HLOC	C-HLOC	I-HLOC	P-HLOC	C-HLOC	I-HLOC	P-HLOC	C-HLOC	I-HLOC	P-HLOC	C-HLOC
	Main-effects	analysis										
Averaged r	.0984	.0446	.0030	.0790	.0174	0744	0138	.0133	.0793	0141	0544	.0343
Lower 95% CI	.0587	0320	0571	.0393	0467	1268	0560	0135	.0401	0525	0956	0035
Upper 95% CI	.1381	.1212	.0632	.1188	.0815	0221	.0285	.0400	.1186	.0242	0132	.0720
k	57	46	49	66	48	53	36	25	28	24	18	19
	Tests for He	terogeneity										
Q	217.21	1067.99	342.46	223.79	274.13	191.69	306.80	104.68	606.79	75.04	81.14	108.09
df	56	45	48	65	47	52	35	24	27	23	17	18
p	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
$\tau^2_{(2)}$	N/A	.0000	.0027	.0009	.0402	.0006	N/A	.0014	N/A	.0005	.0002	.0017
$\tau^{2}_{(3)}$	.0133	.0488	.0275	.0086	N/A	.0147	.0091	.0002	.0054	.0033	.0032	.0014
I <sup>2</sup> (2)	.0000	.0000	.0835	.0839	.9768	.0374	.0000	.6185	.0000	.1099	.0521	.4716
I <sup>2</sup> <sub>(3)</sub>	.8845	.9702	.8657	.8099	.0000	.9018	.9155	.0823	.8902	.7414	.8154	.3780

Notes: C = chance dimension; CI = confidence interval; HLOC = health locus of control; I = internality dimension;  $\beta_{23}$  and  $\beta_{23}$ ; percentage of between-study variation to total variation due to level 2 (multiple measures) and level 3 (studies); respectively; k: number of effect sizes; NA = not applicable (cannot be computed or analysed); P = powerful others dimension;  $\gamma_{23}$  and  $\gamma_{33}$ ; betweenstudies heterogeneity variance due to level 2 (multiple measures) and level 3 (studies); respectively.

#### Results for the global health appraisal

- All the associations are weak to moderate:
  - I-HLOC is related to MQOL (*r* = .11), PQOL (*r* = .11), depression (*r* = −.12), and anxiety (*r* = −.07).
  - P-HLOC is related to PQOL (r = -.08), depression (r = .08), and anxiety (r = .12).
  - C-HLOC is related to MQOL (r = -.16), PQOL (r = -.14), depression (r = .21), and anxiety (r = .16).

	MQOL			PQOL			Depression			Anxiety		
	I-HLOC	P-HLOC	C-HLOC	I-HLOC	P-HLOC	C-HLOC	I-HLOC	P-HLOC	C-HLOC	I-HLOC	P-HLOC	C-HLOC
	Main-effect:	s analysis										
Averaged r	.1087	0152	1643	.1079	0838	1354	1207	.0790	.2146	0730	.1164	.1600
Lower 95% CI	.0349	0811	2449	.0311	1400	2036	1700	.0265	.1729	1331	.0575	.1082
Upper 95% CI	.1826	.0507	0838	.1847	0277	0671	0714	.1315	.2563	0128	.1752	.2118
<i>k</i>	40	41	29	52	45	45	54	47	47	39	36	34
	Tests for he	terogeneity										
Q	120.55	72.44	67.47	185.66	91.94	123.14	153.51	141.25	115.67	159.74	133.75	106.71
df	39	40	28	51	44	44	53	46	46	38	35	33
p	<.001	.0013	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
$\tau_{120}^2$	.0004	.0000	.0000	.0004	.0014	.0019	N/A	N/A	N/A	N/A	.0003	.0145
$\tau_{m}^{\mu\nu}$	.0217	.0148	.0182	.0246	.0084	.0144	.0186	.0190	.0082	.0229	.0191	N/A
$f_{cn}^{d^{(p)}}$	.0116	.0000	.0000	.0112	.0774	.0767	.0000	.0000	.0000	.0000	.0116	.7153
16	.6900	.5900	.6773	.7302	.4669	.5915	.6730	.6941	.4994	.7829	.7481	.0000

Table 2. Summary of tests examining the direction and magnitude of the HLOC-global health appraisal relationships.

Notes: C = chance dimension; Cl = confidence interval; HLOC = health locus of control; I = internality dimension;  $f_{0,2}$  and  $f_{0,2}$ ; percentage of between-study variation to total variation due to level 2 (multiple measures) and level 3 (studies), respectively; k number of effect sizes; NA = not applicable (annot be computed or analysed; MQOL = mental quality of life; P = powerful others dimension; PQOL = physical quality of life;  $r_{1}$  and  $r_{1,2}$ ; between-studies heterogenerality variance due to level 2 (multiple measures) and level 3 (studies), respectively.

- The correlations are generally weak, which is expected in social and behavioral sciences.
- The authors also explored possible moderating effects such as gender composition, age composition, individualism and power distrance (cultural dimensions).

- Similar to other techniques or approaches, meta-analysis is not without its own limitations.
- Combining apples and oranges:
  - Studies are usually with different designs, samples and measures;
  - The combined effect size sometimes may not make sense.
- Possible solutions:
  - Clearer definitions of inclusion criteria;
  - Designs and samples as potential moderators, e.g., experimental vs. observational studies.

- Most researchers accept that published studies are biased (publication bias).
- It is also known as the file drawer problems- Non-significant findings are less likely to be submitted and accepted for publication.
- Possible solutions:
  - Including unpublished findings whenever possible;
  - Testing and plotting potential publication bias.

### Funnel plot



- Systematic review and meta-analysis are powerful tools to synthesize research findings in social, medical, and behavioral sciences.
- These techniques can be used to support evidence-based practice/research.

- Any questions?
- My website: http://mikewlcheung.github.io/
- Source: http://dilbert.com/strip/2010-08-24

