



Systematic literature review on the effectiveness of training and education for the protection of workers

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Presentation Outline

- Background
 - Concepts
 - Earlier literature review
- IWH-NIOSH systematic review
 - What we did
 - What we found
- Discuss in relation to other research
- Questions and answers



Presentation based on recent IWH-NIOSH report

- Robson et al. A systematic review of the effectiveness of training & education for the protection of workers. Toronto: IWH; Cincinnati, OH: NIOSH; 2010
- Technical report and lay summary available from <http://www.iwh.on.ca/sys-reviews/training-and-education-programs>
- Journal manuscript submitted to American Journal Preventive Medicine in spring 2010



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Research question 1

- Does OHS training have a beneficial effect on workers and firms?



What do we mean by OHS training?

- “Planned efforts to facilitate the learning of specific OHS competencies” (based on Noe, 2005)
- Includes both “education” and “training”
- In other words, **includes all types of training**:
 - Training with **low** learner engagement (**passive** training)
 - e.g. lectures, written materials, simple video
 - Training with **high** learner engagement (**active** training)
 - e.g. hands-on practice

Noe RA. Employee training and development. Boston: McGraw-Hill, 2005.



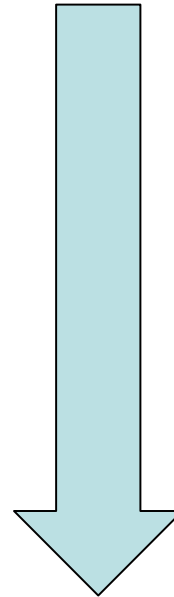
What do we mean by beneficial effect?

- We examined **four categories of occupational health & safety outcomes**
 1. OHS knowledge
 2. OHS attitudes & beliefs
 - e.g. self-efficacy, behavioural intentions
 3. OHS behaviours (on the job)
 - Includes hazards and exposures affected by behaviours
 - e.g. safe work practices, use of personal protective equipment, postures, workstation layout
 4. Health
 - e.g. injuries, illnesses, symptoms



Does your confidence about training effectiveness change with the outcome being discussed?

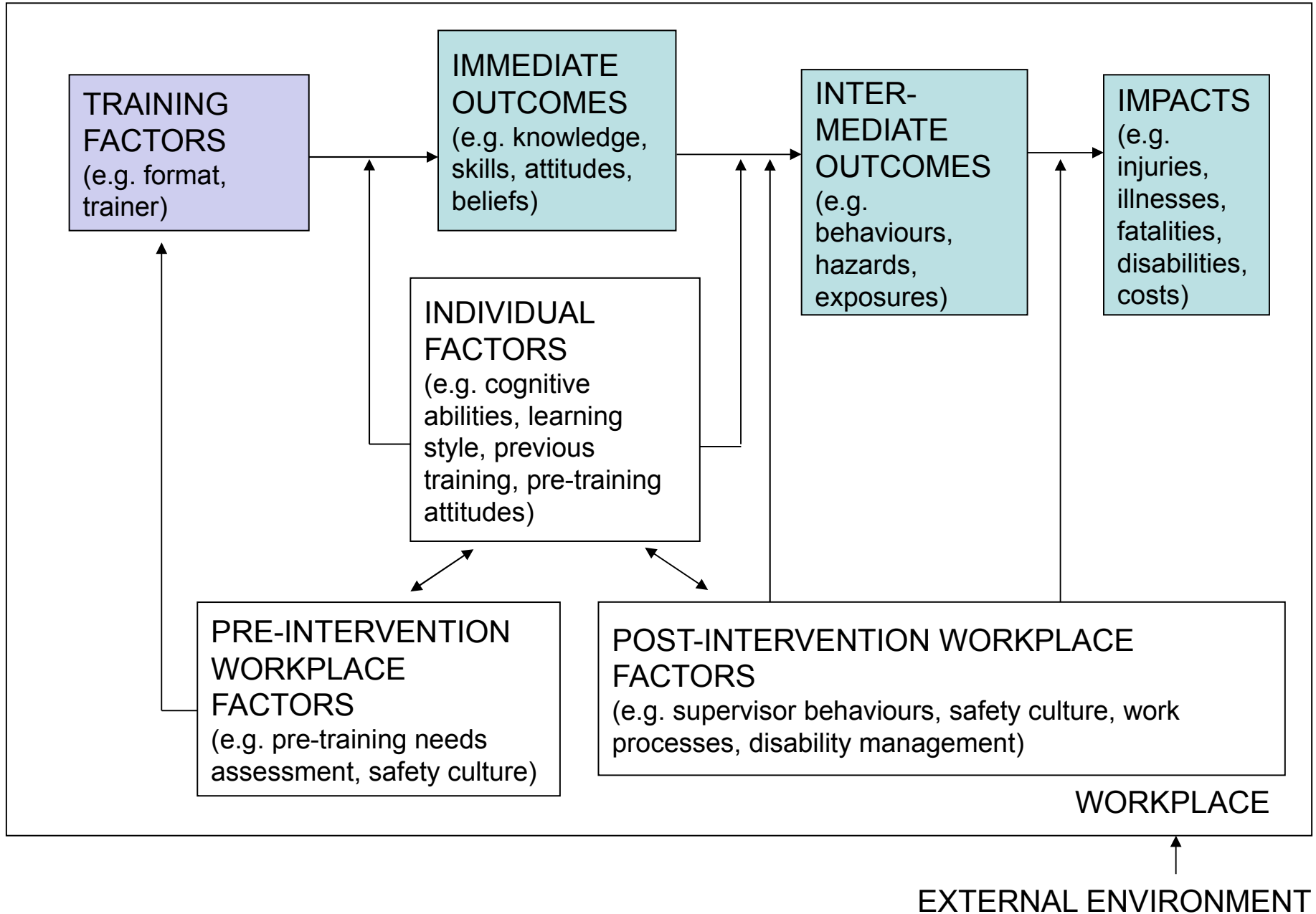
- Knowledge
- Attitudes & beliefs
- Behaviours
- Health



Decreasing
confidence

Why?

Conceptual model of training interventions for primary prevention in OHS





IWH-NIOSH review starts where the earlier review by NIOSH ended

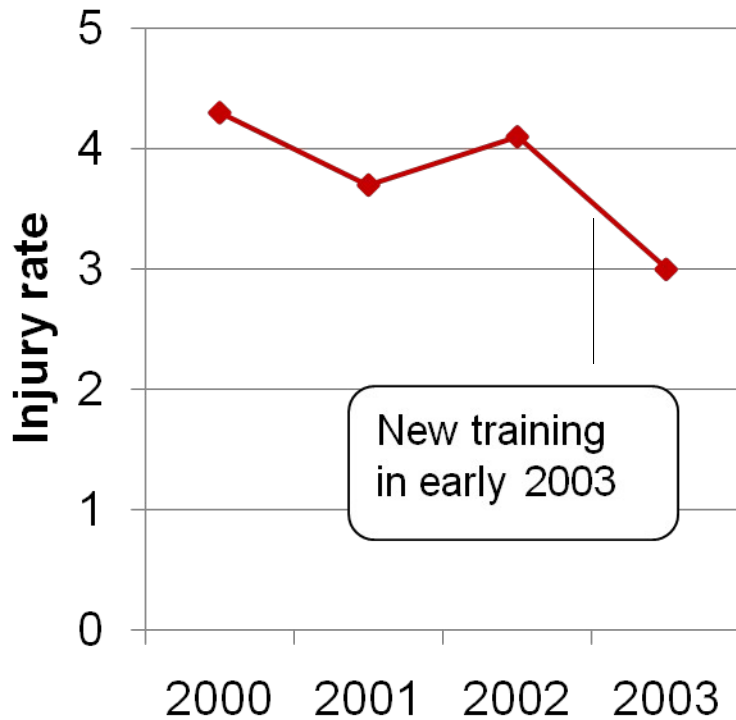
- **Traditional narrative literature review: NIOSH report**
 - 80 intervention studies, from 1980-1996
 - Findings:
 - Training is effective in changing knowledge
 - Training is effective in changing behaviours
 - Training is effective in changing health (i.e. illness & injury)
 - Authors said more rigorous research evidence needed in future
 - Stronger study designs
 - Lack of confidence about the findings on health outcomes

Cohen A et al. Assessing occupational safety and health training: a literature review. Cincinnati, OH: NIOSH, 1998

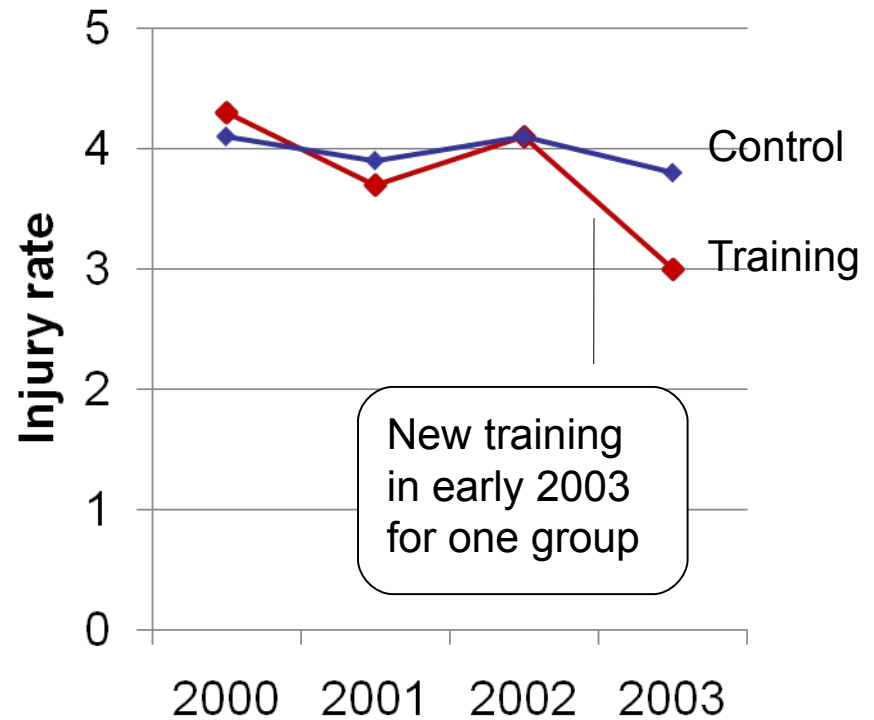


Study design affects confidence in results

Pre-post study design

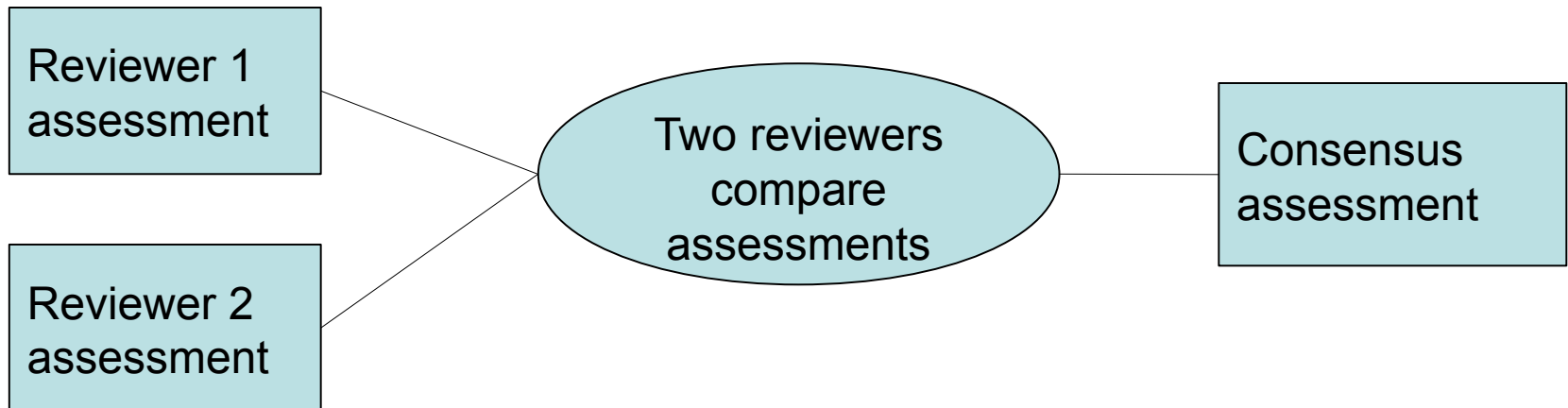


Randomized control trial (RCT) design



Systematic literature review

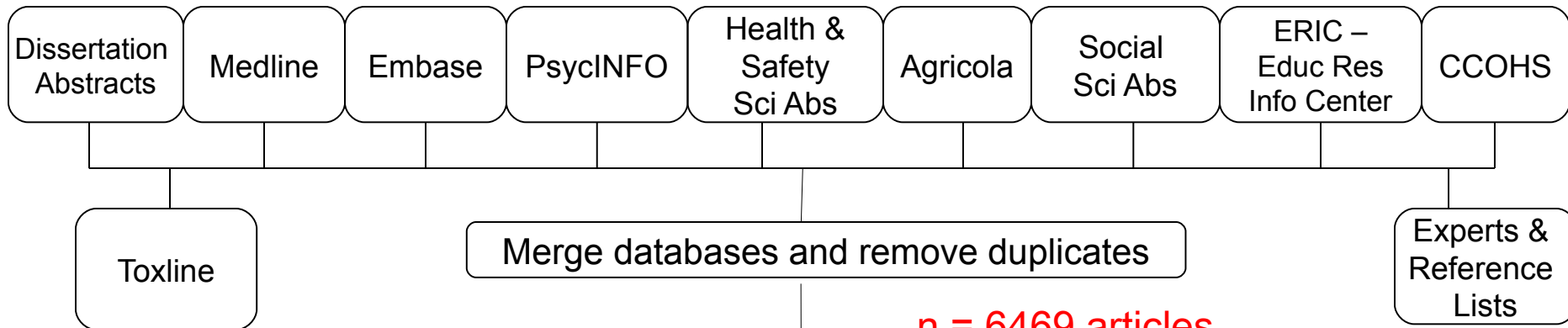
- Different than traditional narrative literature review
- Methods designed to minimize the influence of individual bias
 - Extensive, systematic literature search
 - Explicit, standardized methods for each stage of the review
 - Often use pairs of reviewers:



Step 1: Research Question

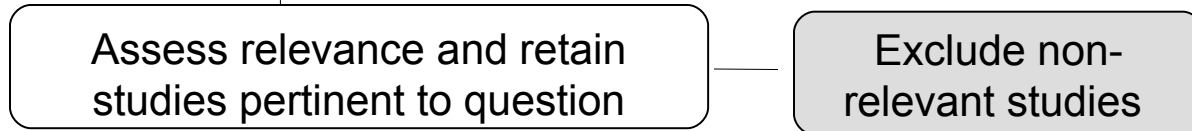
Overview of the review process

Step 2: Literature Search



n = 6469 articles

Step 3: Relevance Assessment

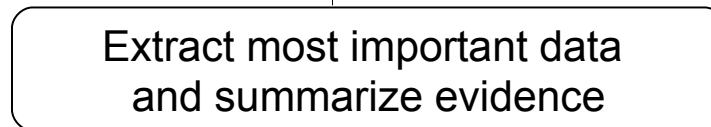


k = 22 studies

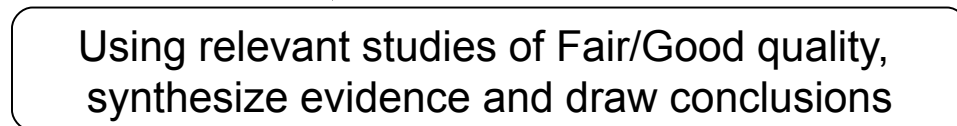
Step 4: Quality Assessment



Step 5: Data Extraction



Step 6: Evidence Synthesis and Conclusions



k = 12



Relevance assessment criteria

Population

- Worker or worker-in-training

Training and education interventions

- Primary prevention of workplace injury or illness (not secondary prevention)

Study design

- Randomized controlled trials
- Pre- and post-intervention measurement of outcome

Outcome

- OHS-related

Publication

- French or English language
- Published between 1996-2007
- Scientific, peer-reviewed journal



Results from screening for relevance:

- What were the characteristics of the 22 relevant studies?



Hazards addressed by training

Hazard category	No. of studies	No. of interventions
Ergonomics - two-thirds office ergonomics	10	15
Traumatic injury	4	6
Chemical	3	5
Physical	3	7
Biological	2	3
ALL HAZARDS	22	36



Methods of delivering training

Method of training delivery	No. of interventions
Lectures	20
Printed materials	14
Hands-on training	14
Feedback	12
Videos	8
Discussions	7
Demonstration	7
Computer instruction	5
Problem-solving	5
Q & A	4
Behaviour modelling	3
Goal-setting	3
Role play	1



Number of training sessions in an intervention

Number of training sessions in intervention	Number of interventions
One	23
Two	8
Three	1
Five	1
Seven	1
TOTAL	34



Number of hours in a training session

Number of hours in a training session	Number of interventions
Less than one	12
One or two	9
Three or more	7
TOTAL	28

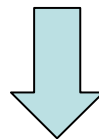


Timing of outcome measurement

Timing of outcome measurement	Number of outcomes
Immediate	8
Short term (≤ 1 mo.)	4
Intermediate term (< 1 mo., ≤ 6 mos.)	18
Long term (> 6 mos)	10
TOTAL	40

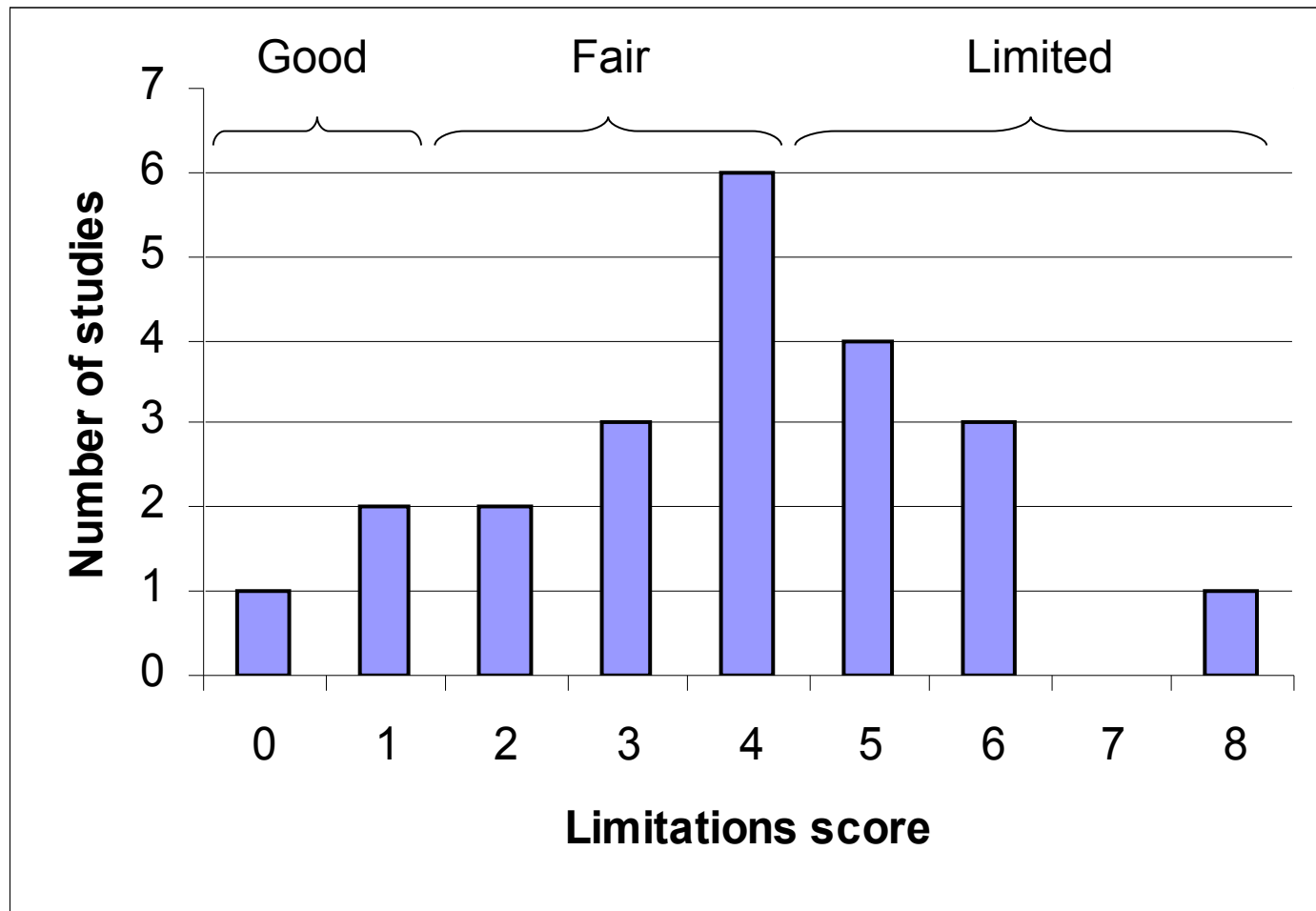
Methodological quality assessment method

- Two raters independently use 15 item form to assess the credibility of the research results (internal validity)
 - Form assesses 4 domains
 - Comparability of study groups
 - Intervention implementation
 - Outcome measurement
 - Statistical analysis



Limitations score
(range 0 to 8)

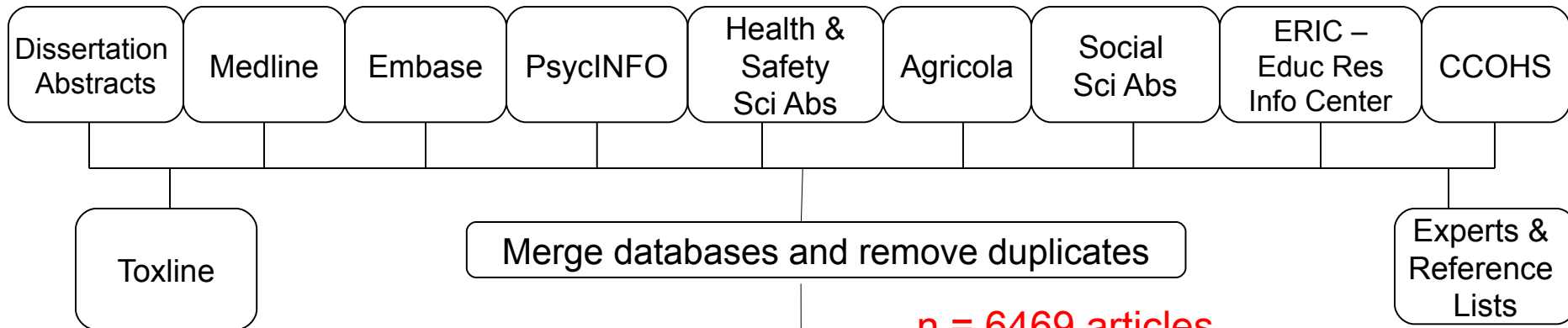
Distribution of methodological quality scores



Step 1: Research Question

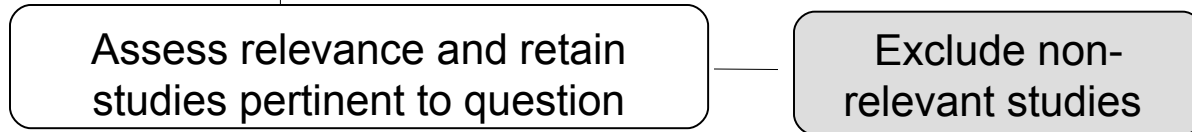
Overview of the review process

Step 2: Literature Search



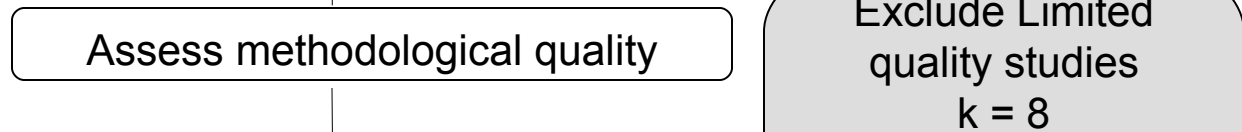
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Step 3: Relevance Assessment

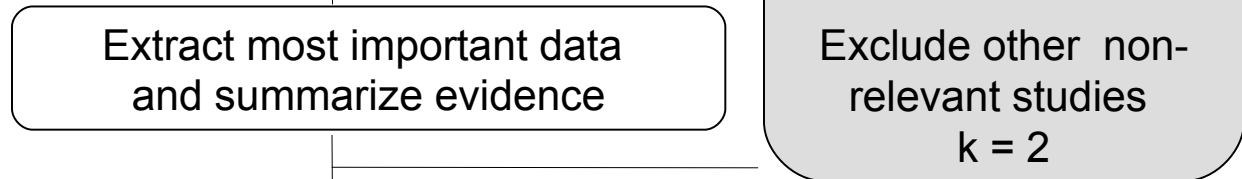


k = 22 studies

Step 4: Quality Assessment



Step 5: Data Extraction



Step 6: Evidence Synthesis and Conclusions



k = 12



Use of evidence synthesis algorithm

Body of evidence: results from multiple studies of training effectiveness

Assess body of evidence using algorithm

Level of evidence	Method. quality	Quantity (min.)	Consistency in directions of effects	Effect size
Strong	Good	2	Yes	Sufficient
	Fair/Good	5	Yes	Sufficient
	Meet criteria for Sufficient level of evidence			Large
Sufficient	Good	1	n/a	Sufficient
	Fair/Good	3	Yes	Sufficient
Insufficient	Any of the above 4 criteria not met			

Strength of the body of evidence determined:

- Insufficient
- Sufficient
- Strong

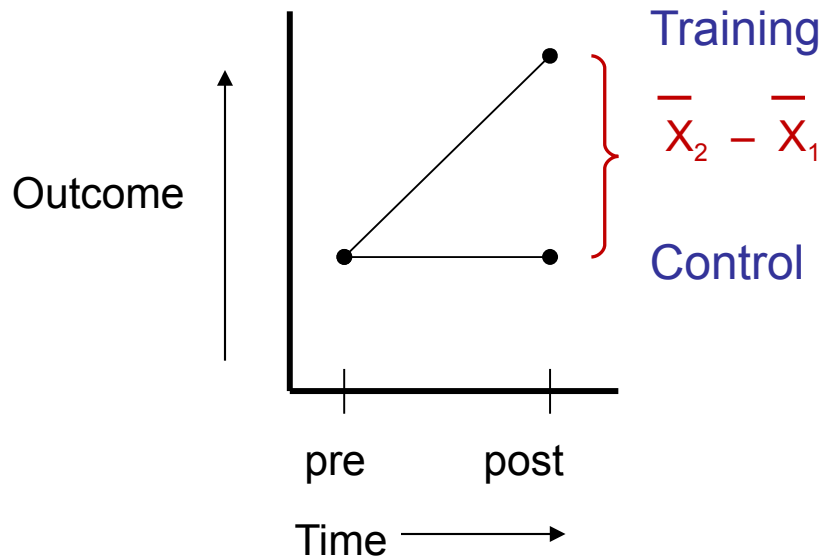


Algorithm used for evidence synthesis

Level of evidence	Method. quality	Quantity (min.)	Consistency in directions of effects	Effect size
Strong	Good	2	Yes	Sufficient
	Fair/Good	5	Yes	Sufficient
	Meet criteria for Sufficient level of evidence			Large
Sufficient	Good	1	n/a	Sufficient
	Fair/Good	3	Yes	Sufficient
Insufficient	Any of the above 4 criteria not met			

Based on Briss et al. (2000) Developing an evidence-based *Guide to Community Preventive Services* – Methods. Am J Prev Med 18(1S):35. (The Guide can also be accessed at <http://www.thecommunityguide.org/index.html>.)

Our review's form of effect size: Standardized mean difference (d)



Standardized mean difference (d)

$$= \frac{\bar{X}_2 - \bar{X}_1}{s_p} \text{ standard deviation}$$

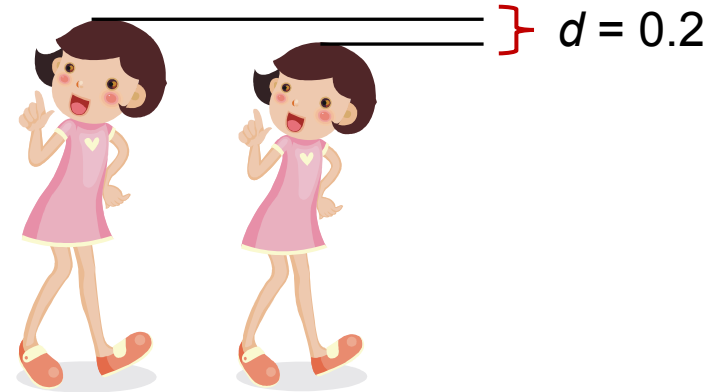
- Expresses effects as a number of standard deviations
- Unitless



Cohen's guidance for understanding standardized mean difference (d)

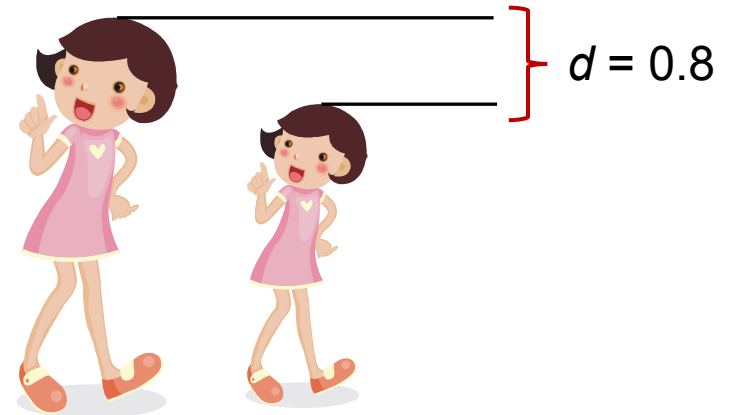
$d = 0.2 \approx$ "Small"

Difference between
average height of 15-yr
old and 16-yr old girls



$d = 0.8$ or more \approx "Large"

Difference between
average height of 13-yr
old and 18-yr old girls




Cohen J (1977) Statistical power analysis for the behavioral sciences, rev ed.
New York: Academic Press.



Effect size criteria for evidence synthesis algorithm set by training research experts on team

Outcome	Training versus control comparisons	
	Sufficient d	Large d
Knowledge	1.0	1.5
Attitudes & Beliefs	0.5	1.0
Behaviours	0.4	0.8
Health	0.15	0.30



Effect size criteria decrease as the outcome becomes more distant from training intervention



Algorithm used for evidence synthesis - behaviours

Level of evidence	Method. quality	Quantity (min.)	Consistency in directions of effects	Effect size
Strong	Good	2	Yes	Sufficient (+0.4)
	Fair/Good	5	Yes	Sufficient (+0.4)
	Meet criteria for Sufficient level of evidence			Large (+0.8)
Sufficient	Good	1	n/a	Sufficient (+0.4)
	Fair/Good	3	Yes	Sufficient (+0.4)
Insufficient	Any of the above 4 criteria not met			



Six studies contributed to evidence synthesis on behaviours

Training intervention	Method of training delivery	1 st author, yr of publication
Office ergonomics	Multi-component, 1 session	Brisson 1999
Office ergonomics	Multi-component, 2 sessions	Eklöf 2004, 2006
Office ergonomics	Multi-component, 2 sessions	Greene 2005
Dermatitis prevention in “wet work” in health care organizations	Multi-component, 3 sessions	Held 2002
Farm safety, farmers	Multi-component, 2 sessions	Rasmussen 2003
Universal Precautions, health care workers	Computer-based, 2 sessions	Wright 2005



Resulting body of evidence on behaviours

Training intervention	Size of effects (<i>d</i>)
Office ergonomics (Brisson 1999)	+0.30, +0.33, +0.18, +0.28
Office ergonomics (Eklöf 2004; 2006)	+1.09, +0.95, +1.71, +1.35, +1.98, +2.36
Office ergonomics (Greene 2005)	+1.16
Dermatitis prevention, HCWs	+0.42
Farm safety, farmers	Not calculable, but positive direction
Universal Precautions, HCWs	+1.25

Median $d = +1.09$

Interquartile range $d = +0.33$ to $+1.35$ (used to judge consistency)





Effects on behaviours relative to evidence synthesis algorithm

Outcome	Status of body of evidence relative to evidence synthesis algorithm			Resulting level of evidence
	Number fair/good studies	Consistency in directions of effects	Median effect size	
Knowledge				
Attitudes				
Behaviours	Enough (6)	Yes	Large (+1.09)	Strong
Health				





Five studies contributing to evidence synthesis on health (i.e. injury, illness, symptoms)

Intervention	Method of training delivery	1 st author, yr of publication
Box cutter use, retail workers	Multi-component, 1 session	Banco 1997
Office ergonomics	Multi-component, 2 sessions	Eklöf 2004, 2006
Office ergonomics	Multi-component, 2 sessions	Greene 2005
Dermatitis prevention in “wet work” in health care organizations	Multi-component, 3 sessions	Held 2002
Farm safety, farmers	Multi-component, 2 sessions	Rasmussen 2003





Effects on health and behaviours relative to evidence synthesis algorithm

Outcome	Status of body of evidence relative to evidence synthesis criteria			Resulting level of evidence
	Number fair/good studies	Consistency in directions of effects	Median effect size	
Knowledge				
Attitudes				
Behaviours	Enough (6)	Yes	Large (+1.09)	Strong
Health	Enough (5)	No	Not sufficient (-0.04)	Insufficient





Effects on all outcomes relative to evidence synthesis algorithm

Outcome	Status of body of evidence relative to evidence synthesis criteria			Resulting level of evidence
	Number Fair/Good studies	Consistency in directions of effects	Median effect size	
 Knowledge	Two few (2)	Yes	Large (+2.52)	Insufficient
 Attitudes	Two few (1)	n/a	Sufficient (+0.84)	Insufficient
Behaviours	Enough (6)	Yes	Large (+1.09)	Strong
Health	Enough (5)	No	Not sufficient (-0.04)	Insufficient



Sensitivity analysis in a research study

- **Tests the robustness of conclusions** when methodological decisions are made differently
- Table on the next slide shows the result of the following sensitivity test:
 - Each research study contributed **only one effect size (d)** to the body of evidence (instead of multiple d 's)
 - when studies had more than one d , we used the median d
 - Studies of **limited methodological quality were included** in evidence synthesis too (not just fair/good)



Results of sensitivity analysis

Outcome	Status of body of evidence relative to evidence synthesis criteria			Resulting level of evidence
	Number of studies	Consistency of directions of effects	Median effect size	
Knowledge	Enough (5)	Yes	Sufficient (+1.27)	Sufficient
Attitudes	Enough (3)	Yes	Sufficient (+0.85)	Sufficient
Behaviours	Enough (10)	Yes	Sufficient (+0.79)	Sufficient
Health	Enough (10)	Yes	Too small (+0.05)	Insufficient

➔ **Conclusions about behaviours and health are robust**



What is your explanation for these findings?

- How can OHS training be found to be ineffective in impacting health?
- Why is there strong evidence of an effect of OHS training on worker practices (behaviours), yet insufficient evidence of an effect on health?



How does this fit with other research evidence? (1)

- Various IWH reviews have not been supportive of OHS training on musculoskeletal disorders
 - Ergonomics training
 - Mixed evidence (Brewer et al. 2006; Amick et al. 2008)
 - Moderate evidence of NO effect (Brewer et al. 2007)
 - Manual lifting training
 - Mixed evidence (Brewer et al. 2007)

Brewer S et al. Workplace interventions to prevent musculoskeletal and visual symptoms and disorders among computer users: A systematic review. J Occup Rehabil 2006;16:325.

Brewer S et al. Systematic review of injury/illness prevention and loss control programs. Toronto: IWH, 2007.

Amick BC et al. Systematic review of the role of OHS interventions in the prevention of upper extremity



How does this fit with other research evidence? (2)

- Cochrane review on lifting training and back pain (Martimo et al. 2008):
 - “No evidence to support use of advice or training in working techniques”

Martimo KP et al. Effect of training and lifting equipment for preventing back pain in lifting and handling: systematic review. *British Medical Journal* 2008; 336:429-431.



How does this fit with other recent research evidence? (3)

	IWH-NIOSH study (2010)	Burke et al. study (2006)*
Behaviours	Median $d = 1.09$	Mean $d = 0.72$
Health	Median $d = -0.04$	Mean $d = 0.25$

* Burke et al. data are restricted to those most comparable to IWH-NIOSH study (involving high engagement training and between-group study designs)

Effects are roughly the same size in both studies

Burke MJ et al. Relative effectiveness of worker safety and health training methods. American Journal of Public Health 2006;96:315.



Practical messages

After considering the evidence from the IWH-NIOSH review:

The review team **recommends** that workplaces continue to conduct education and training programs, since they have a positive impact on worker behaviours. However, OHS training **as a lone intervention** has *not* been demonstrated to have an impact on health (e.g. injuries, symptoms).



Practical messages (cont.)

- We strongly suggest that decision-makers consider more than just training when addressing a risk in the workplace, since **large impacts of training alone cannot be expected**
 - Traditional hierarchy of controls approach:
 - Better to eliminate hazard or use engineering solution
 - Theory and some experimental findings suggest multiple component approach to intervention might be best:
 - e.g. change in policy, equipment & training effective in preventing injuries from lifting patients (Amick et al. 2006)

Amick BC et al. Interventions in health care settings to improve musculoskeletal health: a systematic review. Toronto: IWH; 2006



IWH-NIOSH research question 2

- Does higher engagement OHS training have a greater beneficial effect on workers than lower engagement OHS training?



Prior literature review by Burke et al.

- Meta-analysis
 - 95 studies from 1971-2003
 - Quasi-experimental study designs
 - Outcomes: Knowledge, behaviours, health
 - **Higher engagement training is more effective than lower engagement training**

Burke MJ et al. Relative effectiveness of worker safety and health training methods. American Journal of Public Health 2006;96:315.



Burke et al. review: Mean effect sizes* (*d*) by level of learner engagement

Level of learner engagement	Knowledge	Behaviours	Health
Low	+0.58	+0.65	-0.20
Moderate	+0.66	+0.74	+0.04
High	+1.27	+0.72	+0.25

* Burke et al. data are restricted here to between-group study designs

Burke MJ et al. Relative effectiveness of worker safety and health training methods. American Journal of Public Health 2006;96:315.



Evidence syntheses: higher vs. lower engagement studies

Outcome	Status of body of evidence relative to evidence synthesis algorithm			Level of evidence
	Number Fair/Good studies	Consistency in directions of effects	Median effect size*	
Knowledge	Two few (1)	n/a	Not available	Insufficient
Attitudes	Two few (1)	n/a	Sufficient (+0.12)	Insufficient
Behaviours	Enough (3)	Yes	Insufficient (+0.06)	Insufficient
Health	Two few (1)	n/a	Large (+0.60)	Insufficient

* Effect size criteria of algorithm used with research question 2 are 4x smaller than those used with research question 1



Practical messages:

The review team is unable to make recommendations about the level of learner engagement in training

We suggest that training should be designed to be as engaging as possible for the method of delivery used or the resources employed



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Questions?





Effects contributing to evidence synthesis on health (i.e. injury, illness, symptoms)

Intervention	Size of effects (<i>d</i>)
Box cutter training	+0.06
Office ergonomics (Eklöf 2004; 2006)	-0.13, -1.34, -0.37
Office ergonomics (Greene 2005)	-0.12 [§] , +0.27 [§]
Dermatitis prevention, HCWs	+0.05
Farm safety, farmers	+0.06

[§]Median *d* of conceptually similar measures

Median effect size (*d*) = -0.04

Interquartile range = -0.25 to +0.06



Effect size criteria smaller for comparisons of two trainings

Outcome	Training versus control comparisons		Higher versus lower engagement training comparisons	
	Large d	Sufficient d	Large d	Sufficient d
Knowledge	1.50	1.00	0.38	0.25
Attitudes & Beliefs	1.00	0.50	0.25	0.12
Behaviours	0.80	0.40	0.20	0.10
Health	0.30	0.15	0.08	0.04



Divided by 4