Dartmouth GEISEL SCHOOL OF MEDICINE | Dartmouth Center for IMPLEMENTATION SCIENCE

Experimentally Tested Implementation Strategies in Implementation Research

Hosted by:

Kelly Aschbrenner, PhD
Co-Director, DCIS

Jeremiah Brown, PhD
Director, DCIS

LauraEllen Ashcraft, PhD, MSW
Assistant Professor of Epidemiology
Co-Director, AMETHIST@Penn
Perelman School of Medicine
University of Pennsylvania

Upcoming Events

2nd Annual

Dartmouth Implementation Science Symposium

October 14
8:00AM – 5:00PM ET

Arthur L. Irving Institute for Energy & Society
Hanover, NH

https://impsci.link/symposium2026

Upcoming Events

September Works in Progress

Using Implementation Science for Sustained Impact

The DCIS Implementation Research Core (IRC)
September 16 | 12:00 – 1:00PM ET | Zoom

November Works in Progress

Integration of Eating Disorder Care in an Obesity Medicine Setting: An Early Implementation Study

Elizabeth Lampe, PhD
November 18 | 12:00 – 1:00PM ET | Zoom & In-Person

November Fundamentals

Practical Guidance on How to Conduct Implementation Cost Evaluations

Andria Eisman, PhD
November 11 | 12:00 – 1:00 PM ET | Zoom

December Fundamentals

Optimizing Qualitative Methods in Implementation Research

Andrea Nevedal, PhD & Christopher Koenig, PhD
December 11 | 12:00 – 1:00 PM ET | In-Person

https://impsci.link/events

Dartmouth GEISEL SCHOOL OF MEDICINE | Dartmouth Center for IMPLEMENTATION SCIENCE

Continuing Education

Accreditation and Continuing Education (CE) Credit

In support of improving patient care, Dartmouth Health is jointly accredited by the Accreditation Council for Continuing Medical Education (ACCME), the Accreditation Council for Pharmacy Education (ACPE), and the American Nurses Credentialing Center (ANCC), to provide continuing education for the healthcare team.

American Medical Association (AMA)
Dartmouth Health designates this live activity for a maximum of *1.0 AMA PRA Category 1 Credit(s)™*. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

American Nurses Credentialing Center (ANCC)
Dartmouth Health designates this live activity for a maximum of 1.0 ANCC contact hours.

Association of Social Work Boards (ASWB)
As a Jointly Accredited Organization, Dartmouth Health is approved to offer social work continuing education by the Association of Social Work Boards (ASWB) Approved Continuing Education (ACE) program. Organizations, not individual courses, are approved under this program. Regulatory boards are the final authority on courses accepted for continuing education credit. Social workers completing this course receive 1.0 general continuing education credits.

Other Learners: All other learners may claim CME-designated participation credit. Consult your professional licensing board regarding the applicability and acceptance of CME-designated participation credit for programs certified for credit by organizations accredited by Joint Accreditation for Interprofessional Education.

Dartmouth GEISEL SCHOOL OF MEDICINE | Dartmouth Center for IMPLEMENTATION SCIENCE

Continuing Education

Learning Objectives:

1. Define implementation strategies and their purpose in the field of implementation science.
2. Identify taxonomies of implementation strategies.
3. Articulate the benefits of considering the evidence base for implementation strategies, including describing existing resources to appraise the evidence base.

Dartmouth GEISEL SCHOOL OF MEDICINE | Dartmouth Center for IMPLEMENTATION SCIENCE

Continuing Education

Mobile Text-In Code: 160258

Phone Number: **833-884-3375**

Code expires in 48 hours and is for this session only.

To receive credit for this activity, you must:

1. Have a Dartmouth Health CE for Professionals account *with your mobile number included*. Go to **https://dh.cloud-cme.com** to log in or create an account.
2. Sign-in via a mobile phone: Text **160258** to **833-884-3375** *within 48 hours*.
3. Complete the online evaluation *within 30 days*. Upon completion of the evaluation, the credits will be reflected on your online transcript.

Need Help? Email **clpd.support@hitchcock.org**

Perelman SCHOOL OF MEDICINE
UNIVERSITY of PENNSYLVANIA

SEPTEMBER 9, 2026
DARTMOUTH CENTER FOR IMPLEMENTATION SCIENCE

Experimentally Tested Implementation Strategies in Implementation Research

LauraEllen Ashcraft, PhD, MSW
Assistant Professor of Epidemiology

DEPARTMENT of
BIOSTATISTICS
EPIDEMIOLOGY &
INFORMATICS

Agenda

Introduction & Disclosures

Defining implementation strategies & their importance

Taxonomies for behavior change

Consider the evidence

Resources for evidence-based implementations strategies

Conclusion

Today's readings

Powell, B.J., Waltz, T.J., Chinman, M.J. *et al.* A refined compilation of implementation strategies: results from the Expert Recommendations for Implementing Change (ERIC) project. *Implementation Sci* **10**, 21 (2015). https://doi.org/10.1186/s13012-015-0209-1

Ashcraft, L.E., Goodrich, D.E., Hero, J. *et al.* A systematic review of experimentally tested implementation strategies across health and human service settings: evidence from 2010-2022. *Implementation Sci* **19**, 43 (2024). https://doi.org/10.1186/s13012-024-01369-5

Grimshaw, J.M., Eccles, M.P., Lavis, J.N. *et al.* Knowledge translation of research findings. *Implementation Sci* **7**, 50 (2012). https://doi.org/10.1186/1748-5908-7-50

Learning Objectives

By the end of today's session, you will be able to…

Define what implementation strategies are and their purpose in the field of implementation science

Identify taxonomies of implementation strategies

Articulate the benefits of considering the evidence-base for implementation strategies

Use existing resources to appraise the evidence-base for implementation strategies

Agenda

Introduction & Disclosures

Defining implementation strategies & their importance

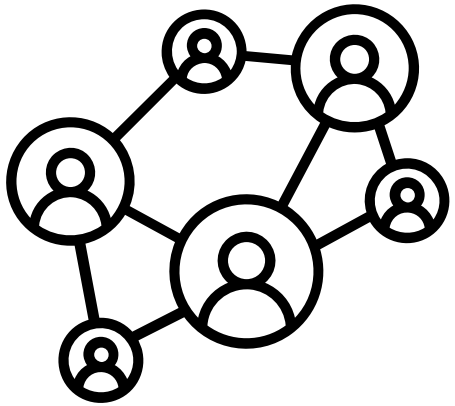
Taxonomies for behavior change

Consider the evidence

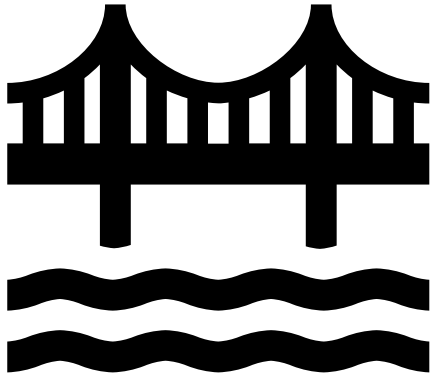
Resources for evidence-based implementations strategies

Conclusion

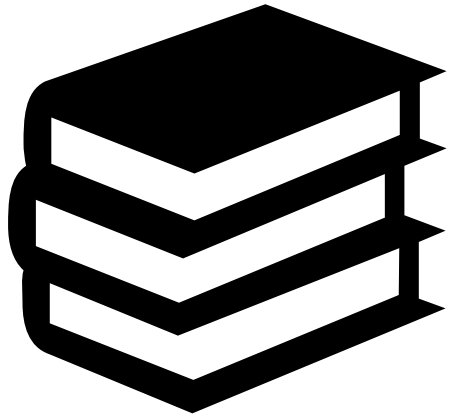
LauraEllen Ashcraft, PhD, MSW



Social worker



Implementation science methodologist



First-generation academic

Disclosures

Research Funding:

US Dept. of Veterans Affairs

National Institutes of Health

Conceptual Disclosures:

To advance the field of implementation science by leveraging theory to promote equity, excellence, and innovation in methods, analysis, and dissemination in health and human services

- Diffusion of Innovations Theory
- TMFs currently using: CFIR, PRISM/REAIM
- TMFs used previously: Model for Dissemination Research, TICD, PARIHS/iPARIHS
- Member of the CFIR Leadership Team
- Associate Editor for *Implementation Science Communications*

Agenda

Introduction & Disclosures

Defining implementation strategies & their importance

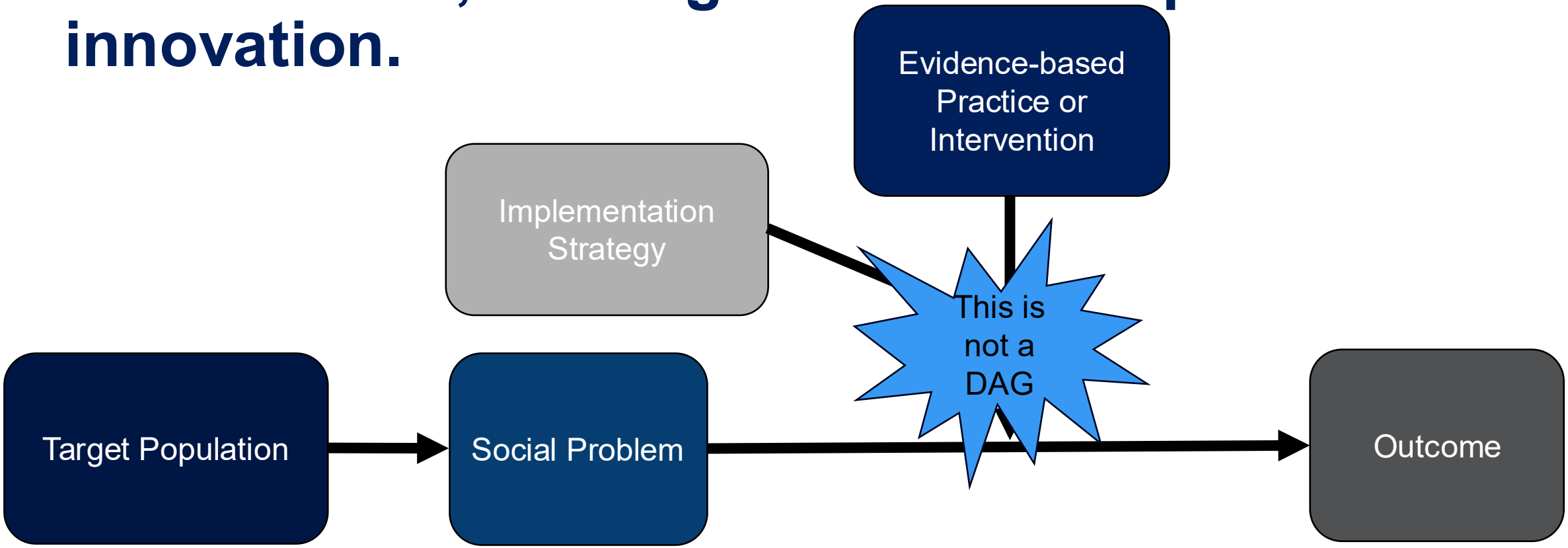
Taxonomies for behavior change

Consider the evidence

Resources for evidence-based implementations strategies

Conclusion

Implementation strategies are often defined as “the stuff we do” to help people, places, communities, and organizations adopt the innovation.



“Implementation strategies are active techniques to enhance the adoption, implementation, and sustainment of research-supported clinical interventions into practice”

implementation strategies are the how of implementation

Proctor et al., 2013; Powell et al., 2012; Powell et al., 2015

Implementation strategies are (often) behavioral interventions in and of themselves. The semantic differences can get complicated.

 It’s important to disentangle and distinguish between innovations, implementation strategies, and research procedures

The four types of implementation strategies can help to select and specify implementation strategies. These categorizations are rarely used in the field.

- Discrete (one at a time)
- Multifaceted (multiple discrete strategies)
- Multilevel (multifaceted, operating at multiple social ecological model levels)
- Blended (multifaceted, often protocolized and branded)

Powell *et al*. A compilation of strategies for implementing clinical innovations in health and mental health. *Med Care Res Rev* 2012

Agenda

Introduction & Disclosures

Defining implementation strategies & their importance

Taxonomies for behavior change

Consider the evidence

Resources for evidence-based implementations strategies

Conclusion

Powell *et al. Implementation Science* (2015) 10:21
DOI 10.1186/s13012-015-0209-1

IMPLEMENTATION SCIENCE

RESEARCH Open Access

A refined compilation of implementation strategies: results from the Expert Recommendations for Implementing Change (ERIC) project

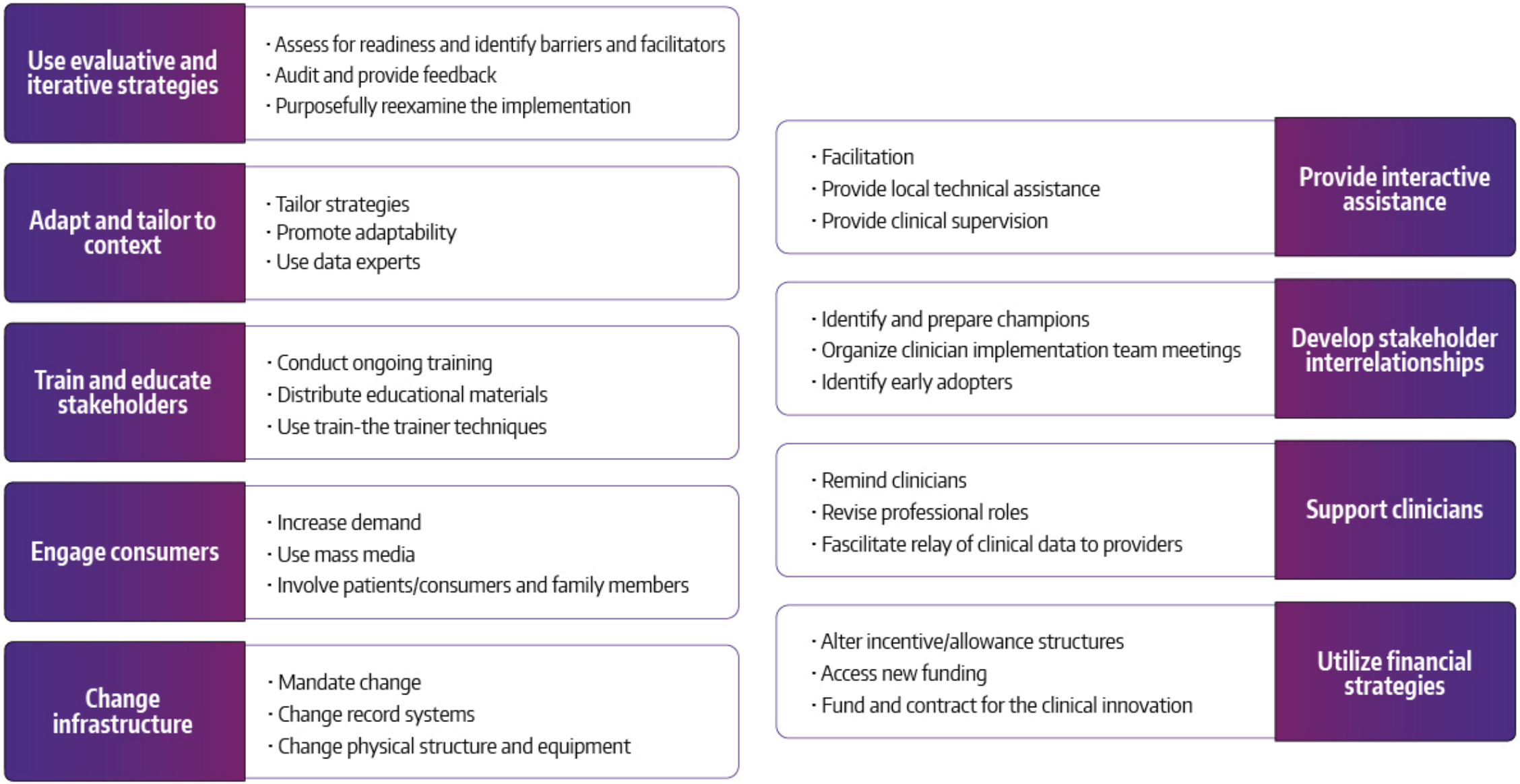
Byron J Powell[1*], Thomas J Waltz[2], Matthew J Chinman[3,4], Laura J Damschroder[5], Jeffrey L Smith[6], Monica M Matthieu[6,7], Enola K Proctor[8] and JoAnn E Kirchner[6,9]

The ERIC project ERIC built consensus about implementation strategies

- Panel of experts in IS and clinical practice
- 3-round Delphi process
- Consensus reached on 73 implementation strategies

Powell et al, *Implement Sci* 2015;10:21

- Access new funding
- Alter incentive/allowance structures
- Alter patient/consumer fees
- Assess for readiness and identify barriers and facilitators
- Audit and provide feedback
- Build a coalition
- Capture and share local knowledge
- Centralize technical assistance
- Change accreditation or membership requirements
- Change liability laws
- Change physical structure and equipment
- Change record system
- Change service sites
- Conduct cyclical small tests of change
- Conduct educational meetings
- Conduct educational outreach visits
- Conduct local consensus discussions
- Conduct local needs assessment
- Conduct ongoing training
- Create a learning collaborative
- Create new clinical teams
- Create or change credentialing and/or licensure standards
- Develop a formal implementation blueprint
- Develop academic partnerships
- Develop an implementation glossary
- Develop and implement tools for quality monitoring
- Develop and organize quality monitoring systems
- Develop disincentives
- Develop educational materials
- Develop resource sharing agreements
- Distribute educational materials
- Facilitate relay of clinical data to providers
- Facilitation
- Fund and contract for clinical innovation
- Identify and prepare champions
- Identify early adopters
- Increase demand
- Inform local opinion leaders
- Intervene with patients/consumers to enhance uptake & adherence
- Involve executive boards
- Involve patients/consumers and family members
- Make billing easier
- Make training dynamic
- Mandate change
- Model and simulate change
- Obtain and use patients/consumers and family feedback
- Obtain formal commitments
- Organize clinician implementation team meetings
- Place innovation on fee for service lists/formularies
- Prepare patients/consumers to be active participants
- Promote adaptability
- Promote network weaving
- Provide clinical supervision
- Provide local technical assistance
- Provide ongoing consultation
- Purposely reexamine the implementation
- Recruit, designate and train for leadership
- Remind clinicians
- Revise professional roles
- Shadow other experts
- Stage implementation scale up
- Start a dissemination organization
- Tailor strategies
- Use advisory boards and workgroups
- Use an implementation adviser
- Use capitated payments
- Use data experts
- Use data warehousing techniques
- Use mass media
- Use other payment schemes
- Use train the trainer strategies
- Visit other sites
- Work with educational institutions


Use evaluative and iterative strategies
· Assess for readiness and identify barriers and facilitators
· Audit and provide feedback
· Purposefully reexamine the implementation
Adapt and tailor to context
· Tailor strategies
· Promote adaptability
· Use data experts
Train and educate stakeholders
· Conduct ongoing training
· Distribute educational materials
· Use train-the trainer techniques
Engage consumers
· Increase demand
· Use mass media
· Involve patients/consumers and family members
Change infrastructure
· Mandate change
· Change record systems
· Change physical structure and equipment
· Facilitation
· Provide local technical assistance
· Provide clinical supervision
Provide interactive assistance
· Identify and prepare champions
· Organize clinician implementation team meetings
· Identify early adopters
Develop stakeholder interrelationships
· Remind clinicians
· Revise professional roles
· Fascilitate relay of clinical data to providers
Support clinicians
· Alter incentive/allowance structures
· Access new funding
· Fund and contract for the clinical innovation
Utilize financial strategies

Caveats about the ERIC project

- Expert panel (n=71) was not globally representative
  - Entirely from North America (97% US, 3% Canada)
  - List generated by study team and their networks
- Focus on health (esp. mental health)
- Evidence base for strategies not considered
- Strategies not tied to theories or models

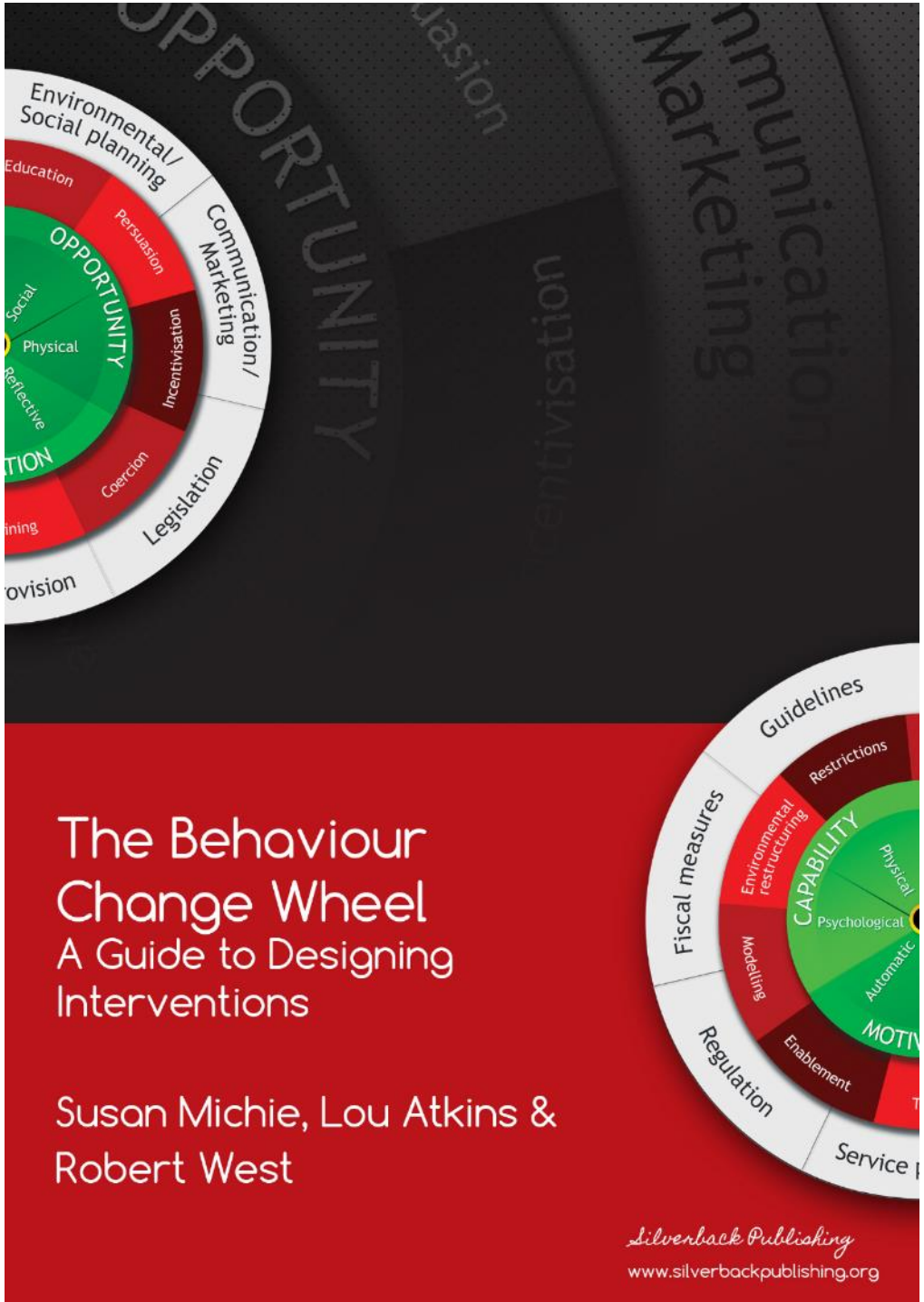
Powell et al, *Implement Sci* 2015;10:21

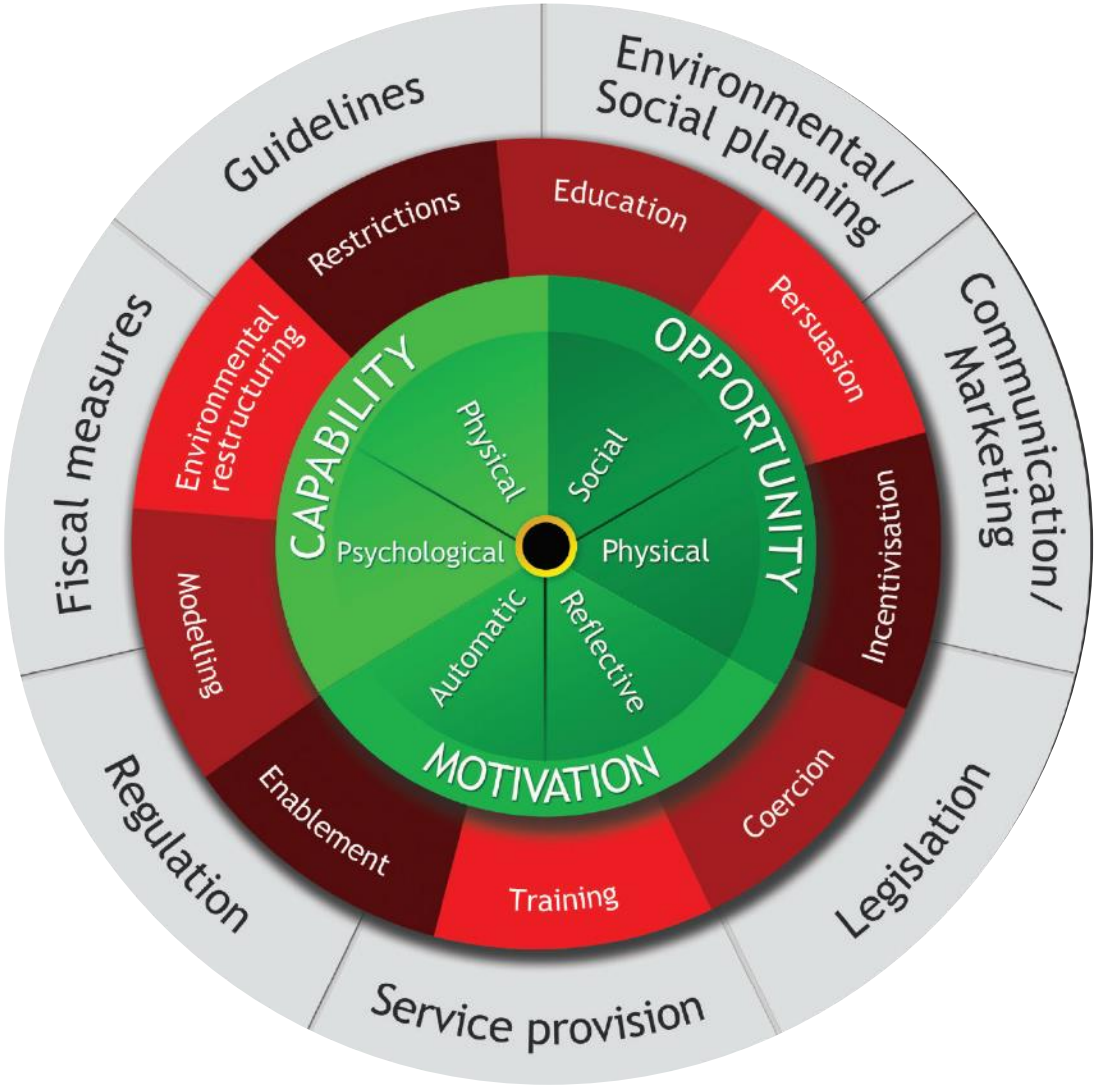
ERIC was meant to be a work in progress

"Future phases of ERIC will focus on:

- developing conceptually distinct categories of strategies
- ratings for each strategy's importance and feasibility
- recommending multifaceted strategies for hypothetical yet real-world scenarios that
  - —vary by sites' endorsement of evidence-based programs and practices
  - —strength of contextual supports that surround the effort"

Powell et al, *Implement Sci* 2015;10:21

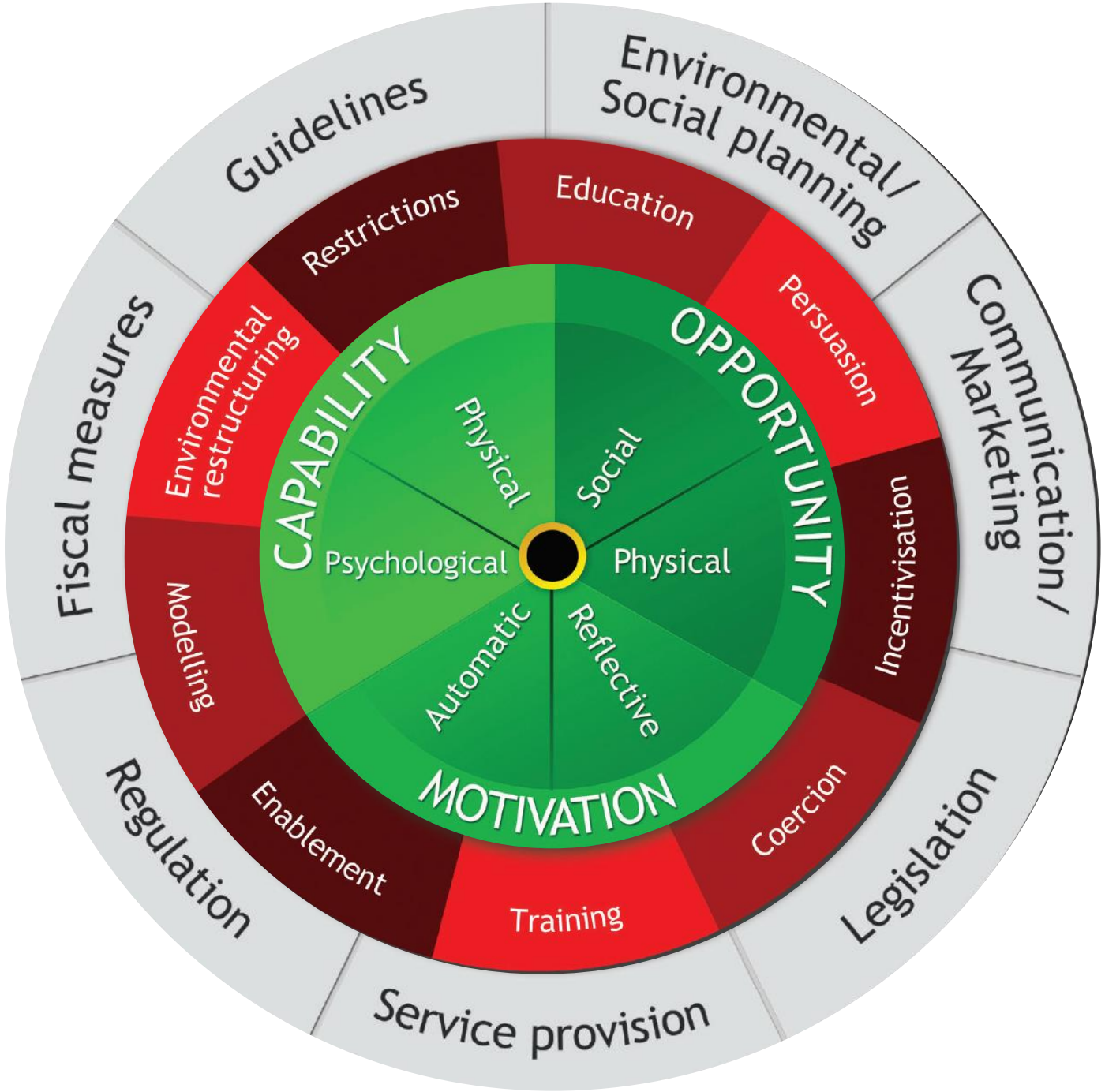

The Behaviour Change Wheel
A Guide to Designing Interventions
Susan Michie, Lou Atkins & Robert West
Silverback Publishing
www.silverbackpublishing.org

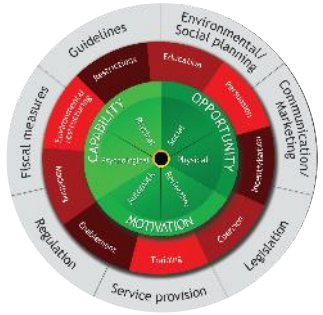

Guidelines
Environmental/ Social planning
Fiscal measures
Communication/ Marketing
Regulation
Legislation
Service provision
Restrictions
Education
Environmental restructuring
Persuasion
CAPABILITY
OPPORTUNITY
Physical
Social
Psychological
Physical
Automatic
Reflective
MOTIVATION
Modelling
Incentivisation
Enablement
Coercion
Training

Reminder about the Behavio(u)r Change Wheel

- Distillation of 19 different behavior change frameworks
- Requires framing the problem (E2P gap) in behavioral terms
  - Meant to apply to individuals, groups, or organizations

Michie S, Atkins L, and West R. *Behavioural Change Wheel*. Silverback Publishing, 2014


Guidelines
Environmental/
Social planning
Communication/
Marketing
Legislation
Service provision
Regulation
Fiscal measures
Restrictions
Education
Persuasion
Incentivisation
Coercion
Training
Enablement
Modelling
Environmental
restructuring
CAPABILITY
OPPORTUNITY
MOTIVATION
Physical
Social
Psychological
Physical
Automatic
Reflective



BCT Taxonomy (v1): 93 hierarchically-clustered techniques

Page	Grouping and BCTs	Page	Grouping and BCTs	Page	Grouping and BCTs
1	**1. Goals and planning**	8	**6. Comparison of behaviour**	16	**12. Antecedents**
	1.1. Goal setting (behavior) 1.2. Problem solving 1.3. Goal setting (outcome) 1.4. Action planning 1.5. Review behavior goal(s) 1.6. Discrepancy between current behavior and goal 1.7. Review outcome goal(s) 1.8. Behavioral contract 1.9. Commitment		6.1. Demonstration of the behavior 6.2. Social comparison 6.3. Information about others' approval		12.1. Restructuring the physical environment 12.2. Restructuring the social environment 12.3. Avoidance/reducing exposure to cues for the behavior
3	**2. Feedback and monitoring**	9	**7. Associations**		
	2.1. Monitoring of behavior by others without feedback 2.2. Feedback on behaviour 2.3. Self-monitoring of behaviour 2.4. Self-monitoring of outcome(s) of behaviour 2.5. Monitoring of outcome(s) of behavior without feedback 2.6. Biofeedback 2.7. Feedback on outcome(s) of behavior		7.1. Prompts/cues 7.2. Cue signalling rew 7.3. Reduce prompts/ 7.4. Remove access to reward 7.5. Remove aversive 7.6. Satiation 7.7. Exposure 7.8. Associative learni		
5	**3. Social support**	10	**8. Repetition and sub**		
	3.1. Social support (unspecified) 3.2. Social support (practical) 3.3. Social support (emotional)		8.1. Behavioral practice/rehearsa 8.2. Behavior substitu 8.3. Habit formation 8.4. Habit reversal 8.5. Overcorrection 8.6. Generalisation of behavior 8.7. Graded tasks		
6	**4. Shaping knowledge**	11	**9. Comparison of out**		
	4.1. Instruction on how to perform the behavior 4.2. Information about Antecedents 4.3. Re-attribution 4.4. Behavioral experiments		9.1. Credible source 9.2. Pros and cons 9.3. Comparative ima future outcomes		
7	**5. Natural consequences**	12	**10. Reward and threa**		
	5.1. Information about health consequences 5.2. Salience of consequences 5.3. Information about social and environmental consequences 5.4. Monitoring of emotional consequences 5.5. Anticipated regret 5.6. Information about emotional consequences		10.1. Material incenti 10.2. Material reward 10.3. Non-specific rew 10.4. Social reward 10.5. Social incentive 10.6. Non-specific inc 10.7. Self-incentive 10.8. Incentive (outco 10.9. Self-reward 10.10. Reward (outco 10.11. Future punishr		
		15	**11. Regulation**		
			11.1. Pharmacological support 11.2. Reduce negative emotions 11.3. Conserving mental resources 11.4. Paradoxical instructions		

10	**8. Repetition and substitution**
	8.1. Behavioral practice/rehearsal 8.2. Behavior substitution 8.3. Habit formation 8.4. Habit reversal 8.5. Overcorrection 8.6. Generalisation of target behavior 8.7. Graded tasks

Agenda

Introduction & Disclosures

Defining implementation strategies & their importance

Taxonomies for behavior change

Consider the evidence

Resources for evidence-based implementations strategies

Conclusion

Which strategies actually work?

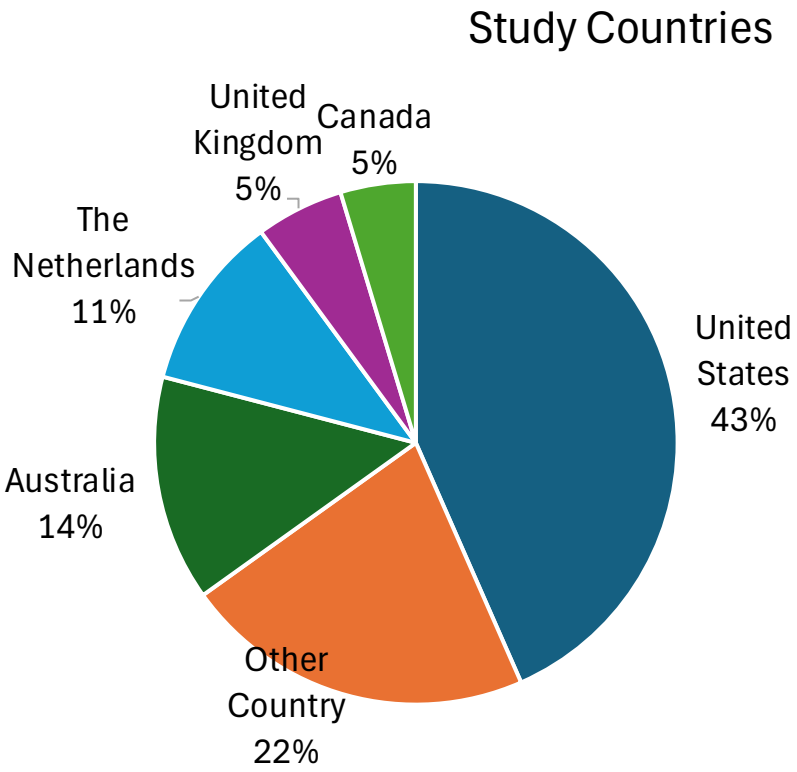
- Some strategies work only under certain circumstances
- Most strategies result in modest improvements (no “magic bullet”)
  - This is a justification for combining strategies

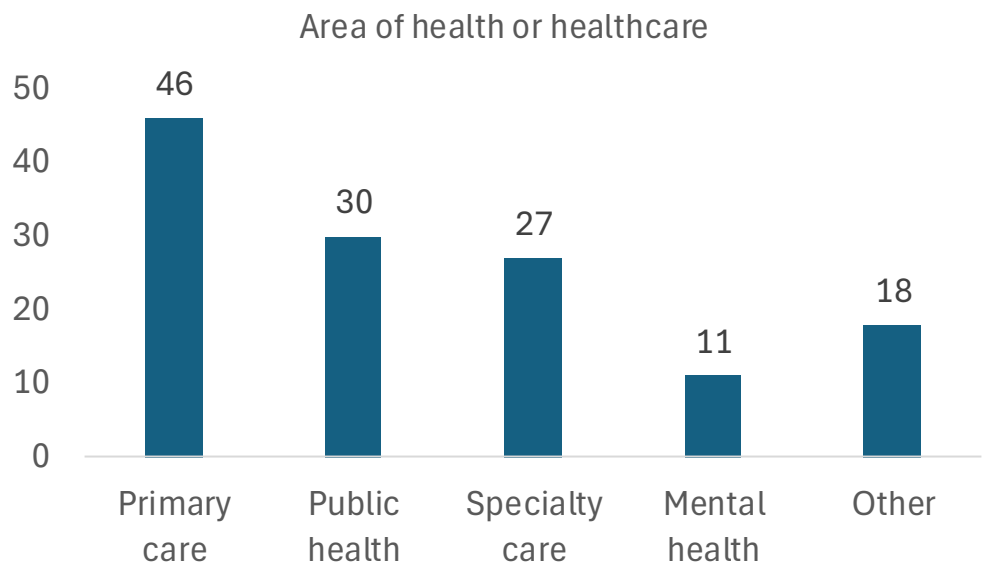
SYSTEMATIC REVIEW Open Access

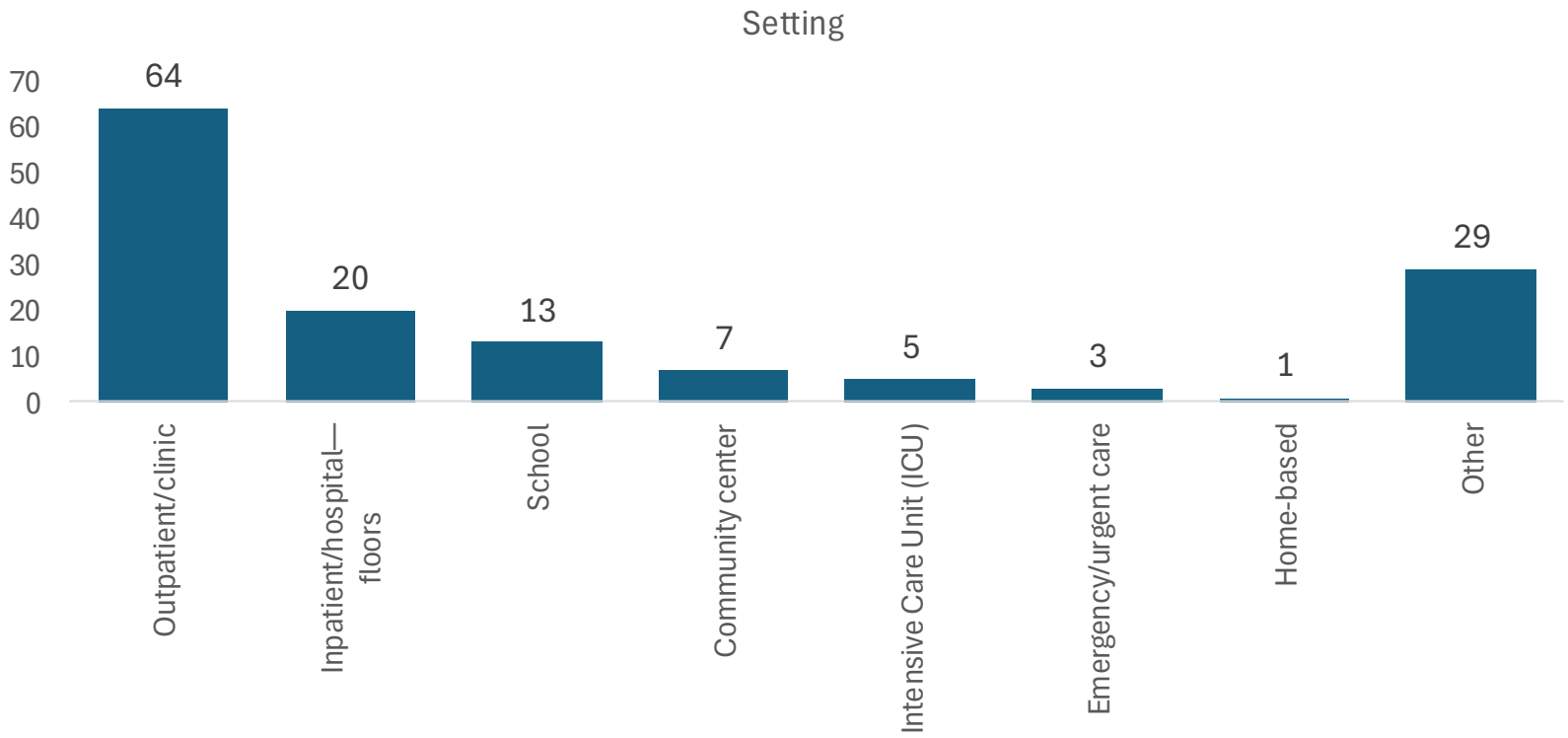
A systematic review of experimentally tested implementation strategies across health and human service settings: evidence from 2010-2022

Laura Ellen Ashcraft[1,2*], David E. Goodrich[3,4,5], Joachim Hero[6], Angela Phares[3], Rachel L. Bachrach[7,8], Deirdre A. Quinn[3,4], Nabeel Qureshi[6], Natalie C. Ernecoff[6], Lisa G. Lederer[5], Leslie Page Scheunemann[9,10], Shari S. Rogal[3,11†] and Matthew J. Chinman[3,4,6†]

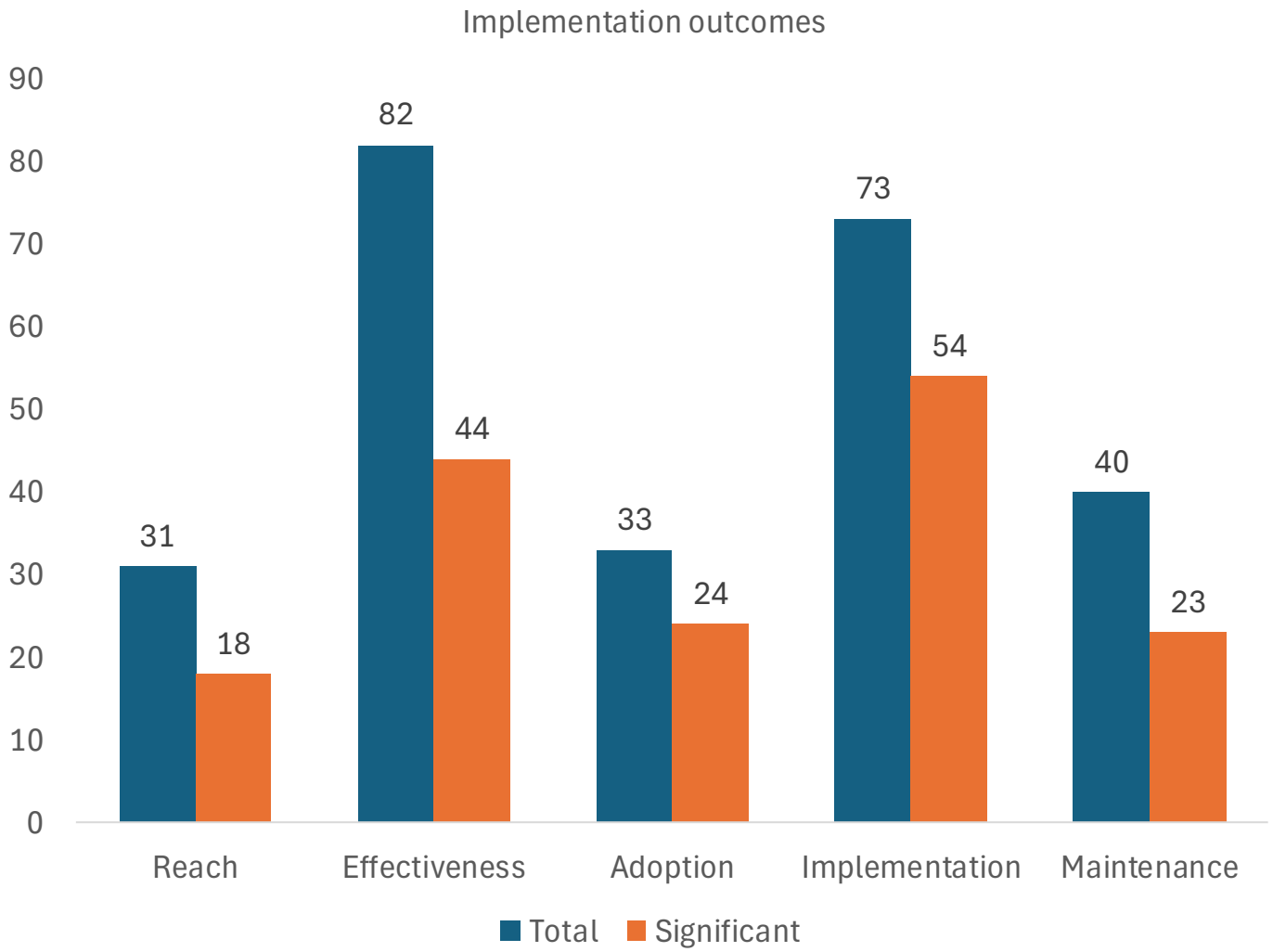
Study Characteristics







Study Characteristics



29
(12-49)
Median number of sites

1,419
(306-5,957)
Median number of participants

1.64
(0-20)
Mean number of Control Arm Strategies

8.33
(1-21)
Mean number of Experimental Arm Strategies

6.73
(0-20)
Mean number of Tested Strategies

Mostly frequently used ERIC implementation strategies

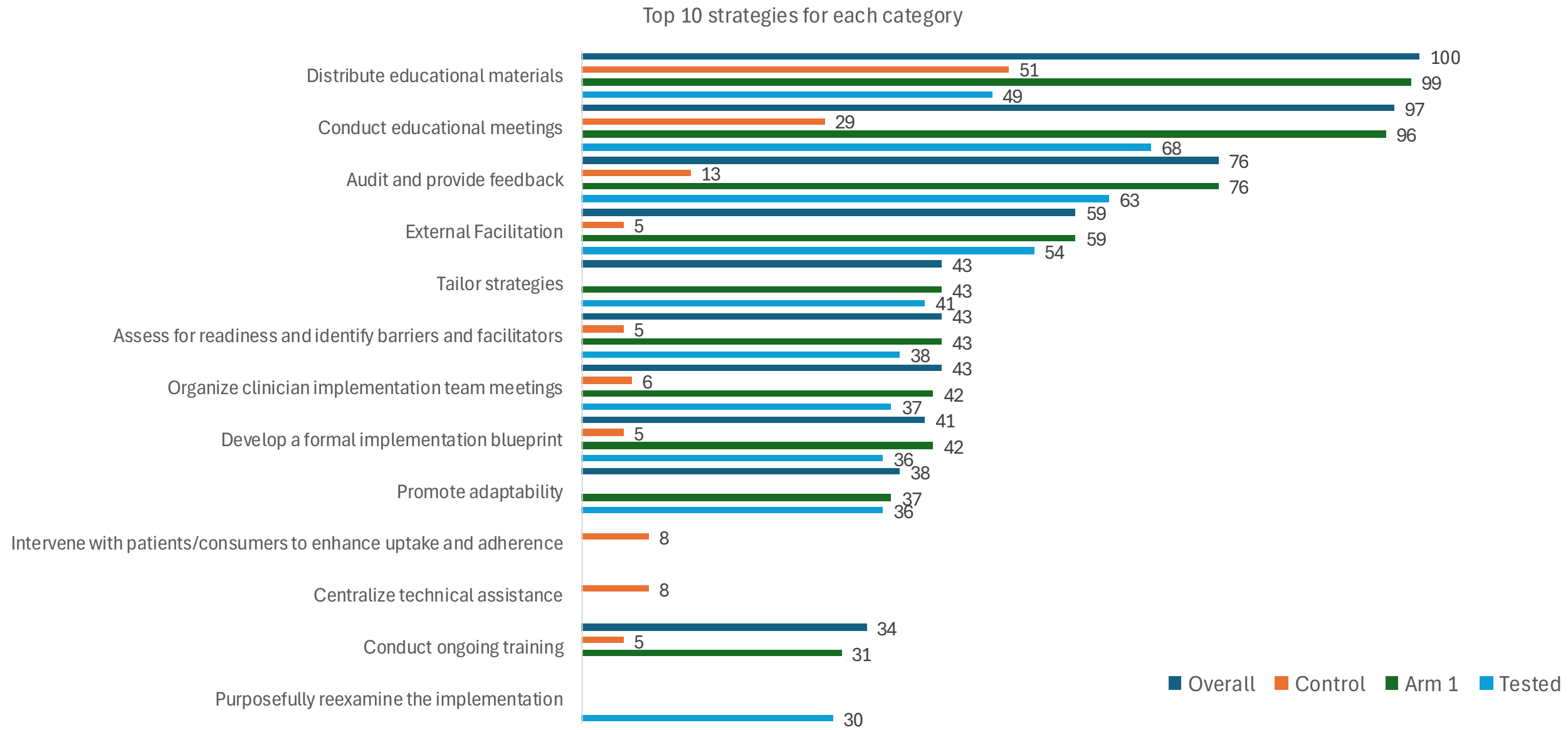
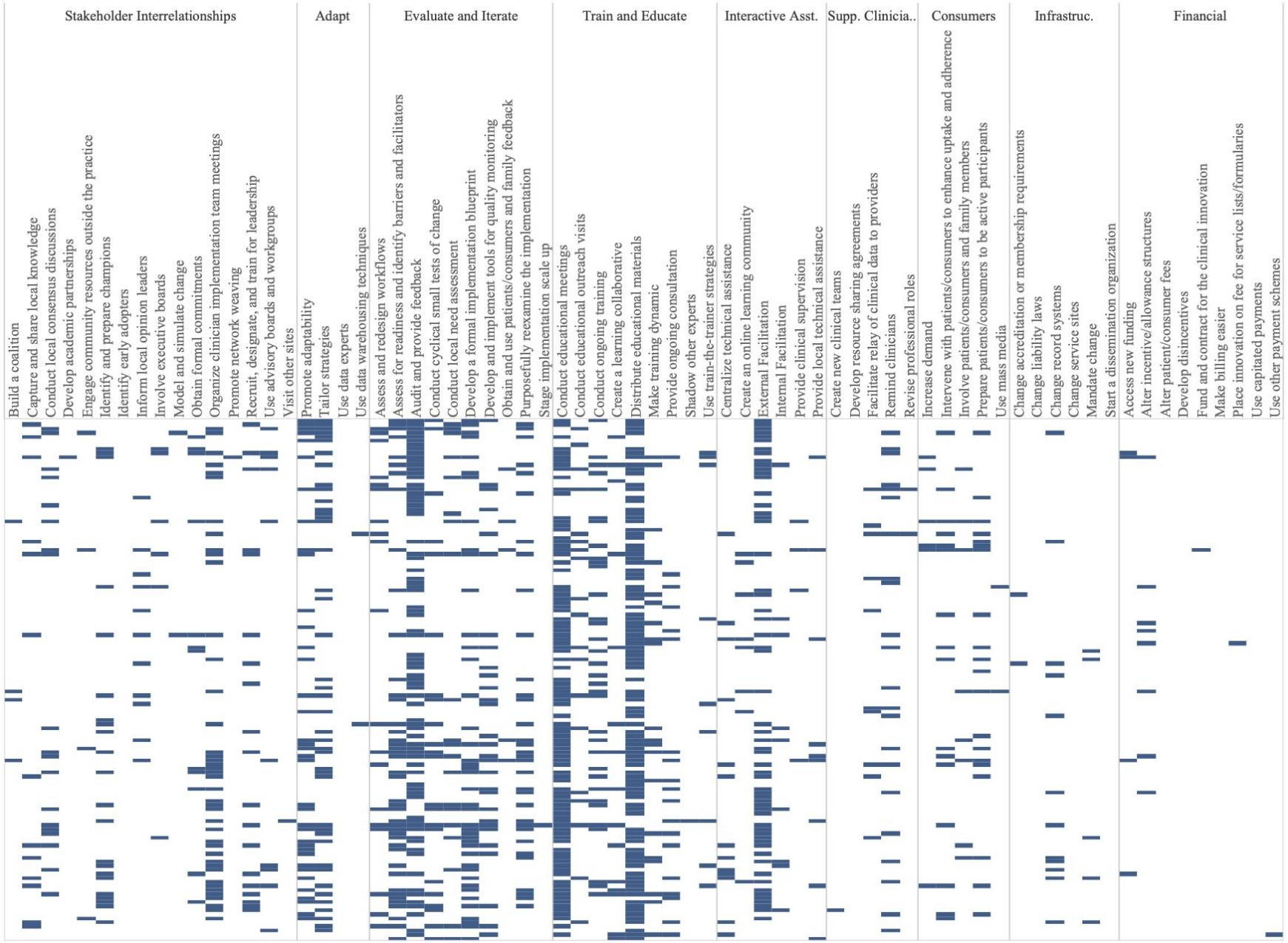


Figure 2. Implementation strategies used in the Experimental Arm of included studies



Interactive visualization linked here!

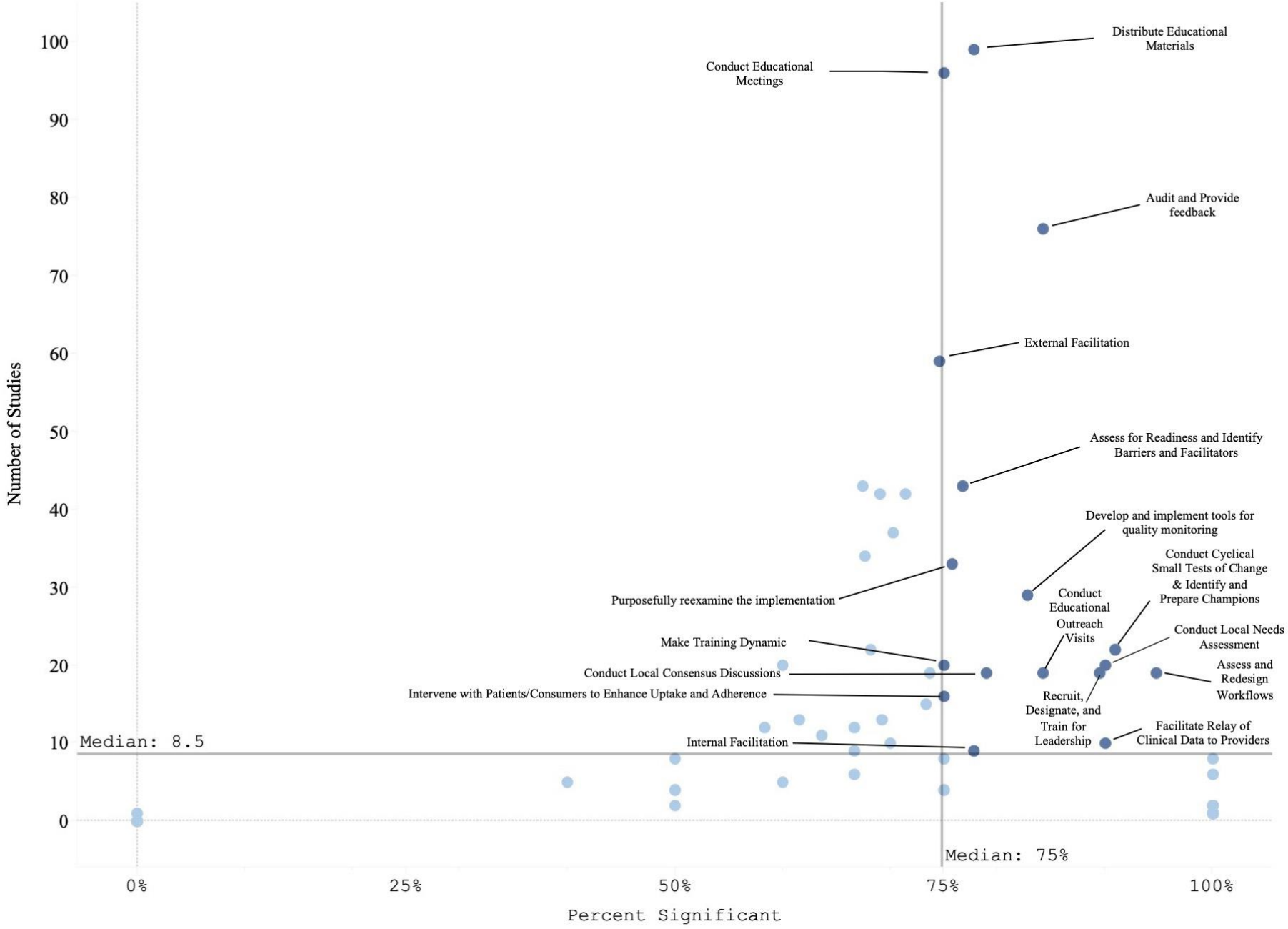
bitly

Table 3. Top 5 commonly used strategies in the Experimental Arm and their 10 most common pairings, organized by cluster

Implementation Strategy	Audit and provide feedback^ [76 studies]	External Facilitation^ [59 studies]	Tailor Strategies [43 studies]	Assess for readiness and identify barriers and facilitators^ [43 studies]	Organize clinician implementation team meetings [42 studies]
Distribute educational materials^	57	48	36	36	35
Conduct educational meetings^	55	52	33	39	36
Audit and provide feedback^	0	38	27	28	22
External Facilitation^	38	0	27	30	31
Tailor strategies	27	27	0	25	19
Assess for readiness and identify barriers and facilitators^	28	30	25	0	22
Organize clinician implementation team meetings	22	31	19	22	0
Develop a formal implementation blueprint	24	27	20	25	26
Promote adaptability	22	22	19	22	19
Conduct ongoing training	15	20	15	15	15
Purposefully reexamine the implementation^	27	24	15	24	20
Develop and implement tools for quality monitoring^	22	13	10	14	13

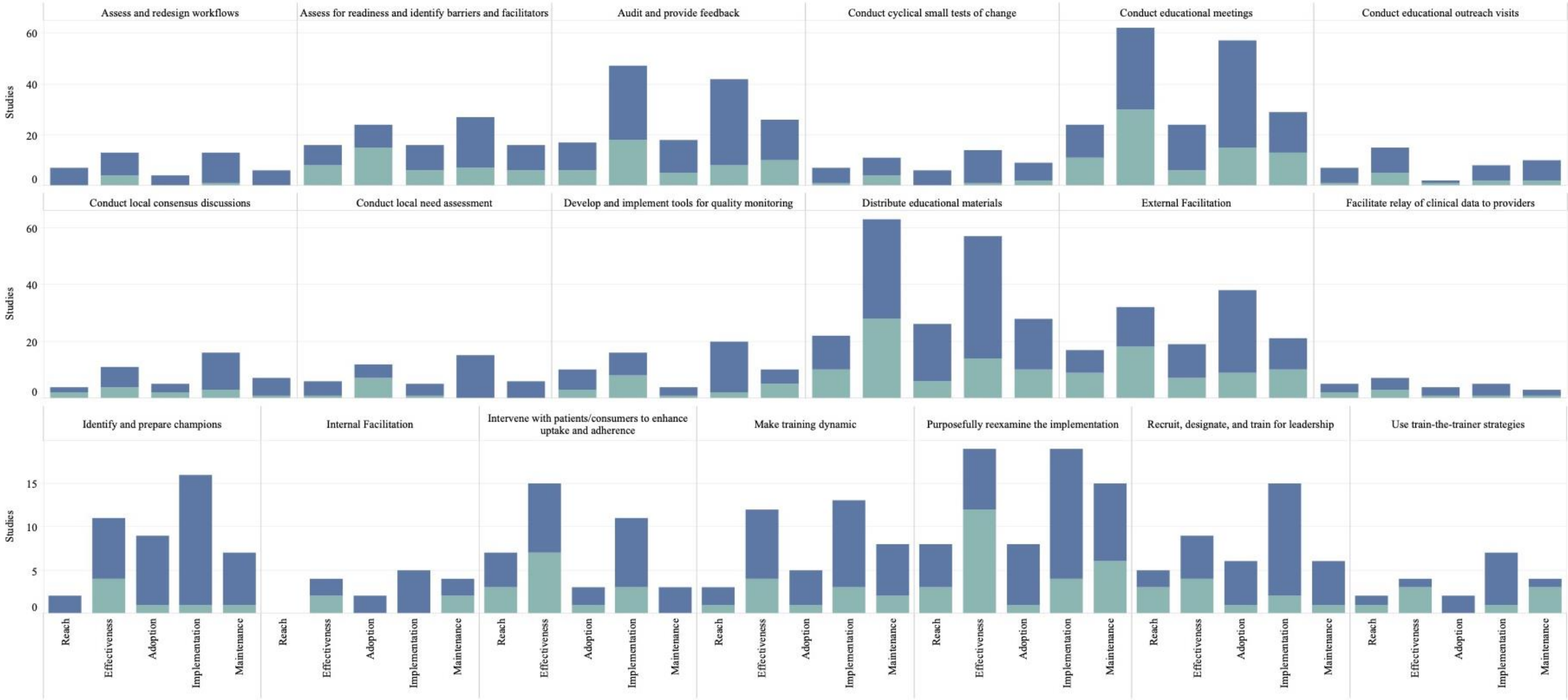
Interactive visualization linked here!

Figure 3. Experimental Arm Implementation Strategies with significant RE-AIM outcome



Interactive visualization linked here!

Figure 4. RE-AIM outcomes for the 19 Top-Right Quadrant Implementation Strategies



Interactive visualization linked here!

There continue to be more systematic reviews of implementation strategies focused on specific strategies and/or clinical settings.

Jolliffe, L., Lannin, N.A., Larcombe, S. *et al.* Training and education provided to local change champions within implementation trials: a rapid systematic review. *Implementation Sci* **20**, 8 (2025). https://doi.org/10.1186/s13012-025-01416-9

Fontaine, G., Vinette, B., Weight, C. *et al.* Effects of implementation strategies on nursing practice and patient outcomes: a comprehensive systematic review and meta-analysis. *Implementation Sci* **19**, 68 (2024). https://doi.org/10.1186/s13012-024-01398-0

Derksen, C., Walter, F.M., Akbar, A.B. *et al.* The implementation challenge of computerised clinical decision support systems for the detection of disease in primary care: systematic review and recommendations. *Implementation Sci* **20**, 33 (2025). https://doi.org/10.1186/s13012-025-01445-4

Fasugba, O., Cheng, H., Dale, S. *et al.* Finding the right dose: a scoping review examining facilitation as an implementation strategy for evidence-based stroke care. *Implementation Sci* **20**, 4 (2025). https://doi.org/10.1186/s13012-025-01415-w

Agenda

Introduction & Disclosures

Defining implementation strategies & their importance

Taxonomies for behavior change

Consider the evidence

Resources for evidence-based implementations strategies

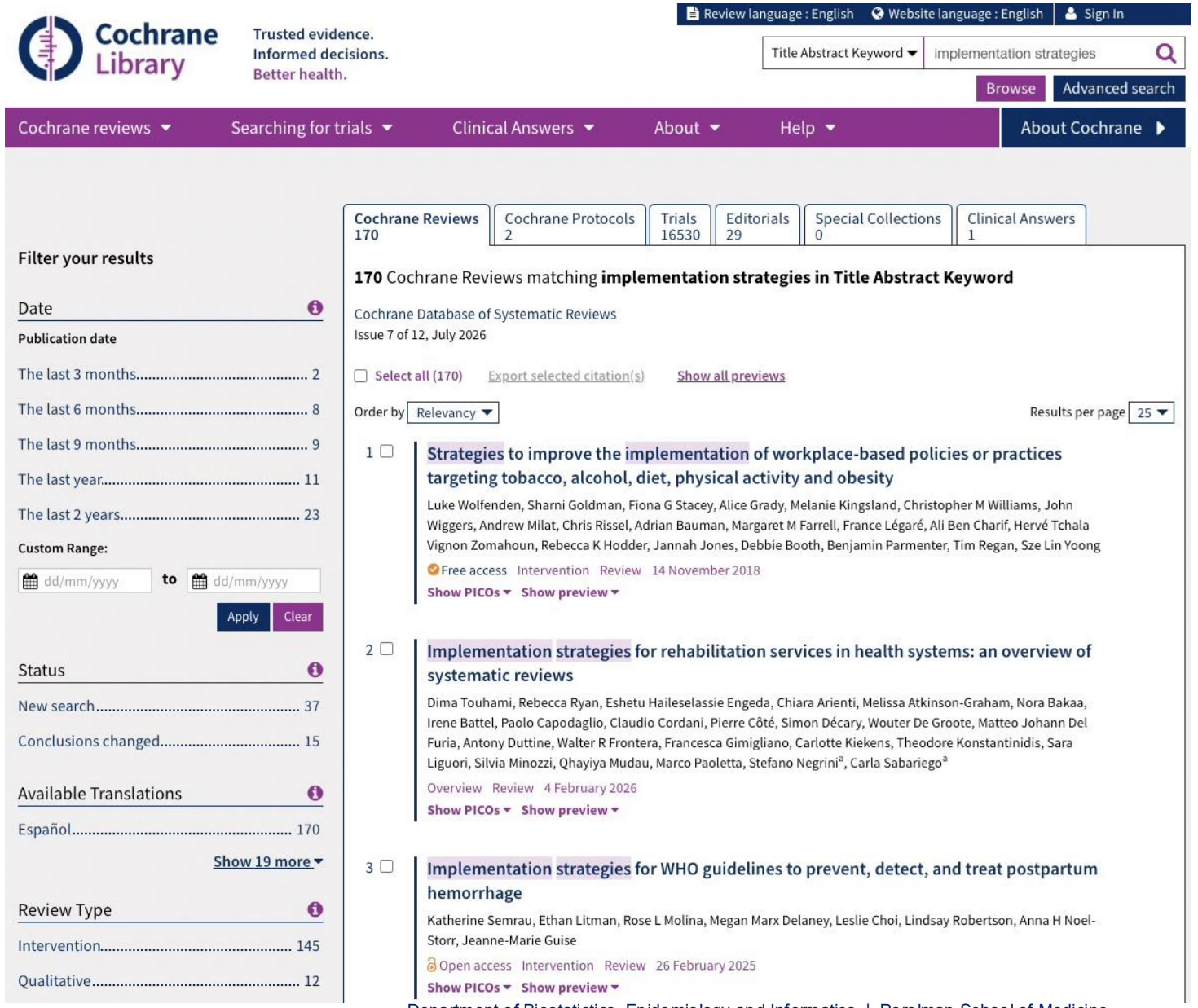
Conclusion

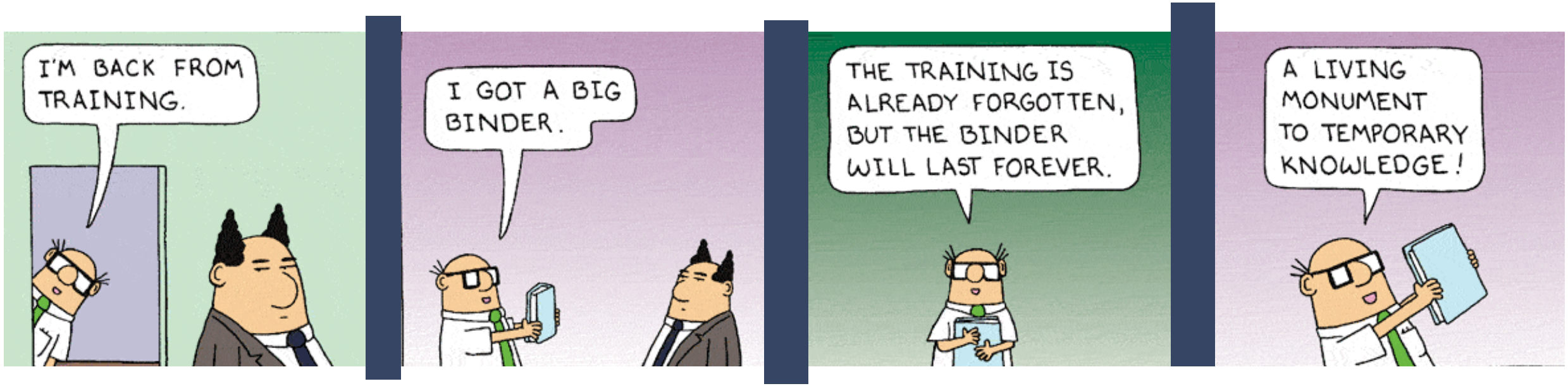
Which implementation strategies are most effective?

Strategy Review	Number of Trials	Effect Sizes
Printed Educational Materials	14 Randomized Trials 31 ITS	Median absolute improvement 2.0% (range 0% to 11%)
Educational Meetings	81 Randomized Trials	Median absolute improvement 6% (IQR 1.8% to 15.3%)
Educational Outreach	69 Randomized Trials	Median absolute improvement in prescribing behaviors 4.8% (IQR 3% to 6.6%), other behaviors 6% (IQR 3.6% to 16%)
Local Opinion Leaders	18 Randomized Trials	Median absolute improvement 12% (6% to 14.5%)
Audit and Feedback	140 Randomized Trials	Median absolute improvement 4.3% (IQR .5 to 16%)
Computerized Reminders	28 Randomized Trials	Median absolute improvement 4.2% (IQR .8 to 18.8%)
Tailored Interventions	26 Randomized Trials	Meta-regression using 15 trials; pooled odds ratio of 1.56 (95% CI, 1.27 to 1.93, $p < .001$)

Slide from Byron Powell by way of Rinad Beidas, adapted from Grimshaw et al 2012

The Cochrane Library database of systematic reviews is a helpful resource to identify evidence for implementation strategies.




I'M BACK FROM TRAINING.
I GOT A BIG BINDER.
THE TRAINING IS ALREADY FORGOTTEN, BUT THE BINDER WILL LAST FOREVER.
A LIVING MONUMENT TO TEMPORARY KNOWLEDGE!

Agenda

Introduction & Disclosures

Defining implementation strategies & their importance

Taxonomies for behavior change

Consider the evidence

Resources for evidence-based implementations strategies

Conclusion

Learning Objectives

By the end of today's session, you will be able too…

Define what implementation strategies are their purpose in the field of implementation science

Identify taxonomies of implementation strategies

Articulate the benefits of considering the evidence-base for implementation strategies

Use existing resources to appraise the evidence-base for implementation strategies

Thank you!

Contact me:
Lauraellen.Ashcraft@pennmedicine.upenn.edu

Dartmouth GEISEL SCHOOL OF MEDICINE | Dartmouth Center for IMPLEMENTATION SCIENCE

Continuing Education

Mobile Text-In Code: 160258

Phone Number: **833-884-3375**

Code expires in 48 hours and is for this session only.

To receive credit for this activity, you must:

1. Have a Dartmouth Health CE for Professionals account *with your mobile number included*. Go to **https://dh.cloud-cme.com** to log in or create an account.
2. Sign-in via a mobile phone: Text **160258** to **833-884-3375** *within 48 hours*.
3. Complete the online evaluation *within 30 days*. Upon completion of the evaluation, the credits will be reflected on your online transcript.

Need Help? Email **clpd.support@hitchcock.org**

Dartmouth GEISEL SCHOOL OF MEDICINE | Dartmouth Center for IMPLEMENTATION SCIENCE

Learning Opportunities at Dartmouth

Seminar Series

Fundamentals of Implementation Science

Monthly on the 2nd Wednesday
12:00 – 1:00PM ET
Virtual

Works in Progress

Monthly on the 3rd Wednesday
12:00 – 1:00PM ET
In Person & Virtual

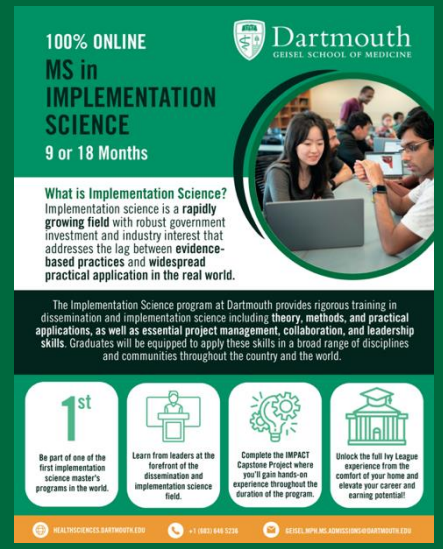
Hosted by:

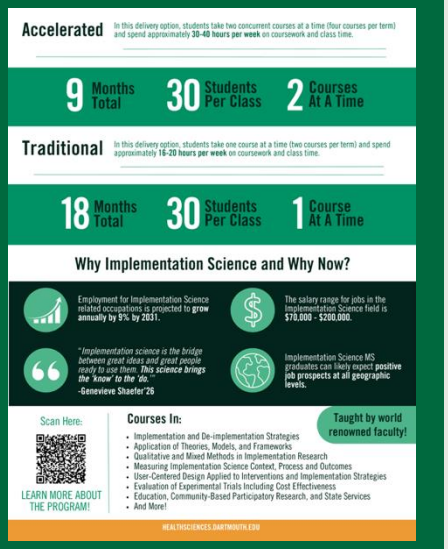
Jeremiah Brown, PhD, DCIS Director
Kelly Aschbrenner, PhD, DCIS Co-Director
Sarah Lord, PhD, DCIS Co-Director

implementation.science@dartmouth.edu

MS in Implementation Science

Dartmouth GEISEL SCHOOL OF MEDICINE
MS in IMPLEMENTATION SCIENCE





Join Our **Network**

impsci.link
impsci.link/linkedin
implementation.science@dartmouth.edu

NIH National Institute of General Medical Sciences

The Dartmouth Center for Implementation Science is a Center of Biomedical Research Excellence (COBRE) supported by the National Institute of General Medical Sciences (NIGMS) of the National Institutes of Health (NIH) under Award Number P20GM156710