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A research agenda to advance the study of implementation mechanisms

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Abstract

Background Implementation science scholars have made significant progress identifying factors that enable or obstruct the implementation of evidence-based interventions, and testing strategies that may modify those factors. However, little research sheds light on *how or why* strategies work, in what contexts, and for whom. Studying implementation mechanisms—the processes responsible for change—is crucial for advancing the field of implementation science and enhancing its value in facilitating equitable policy and practice change. The Agency for Healthcare Research and Quality funded a conference series to achieve two aims: (1) develop a research agenda on implementation mechanisms, and (2) actively disseminate the research agenda to research, policy, and practice audiences. This article presents the resulting research agenda, including priorities and actions to encourage its execution.

Method Building on prior concept mapping work, in a semi-structured, 3-day, in-person working meeting, 23 US-based researchers used a modified nominal group process to generate priorities and actions for addressing challenges to studying implementation mechanisms. During each of the three 120-min sessions, small groups responded to the prompt: “What actions need to be taken to move this research forward?” The groups brainstormed actions, which were then shared with the full group and discussed with the support of facilitators trained in structured group processes. Facilitators grouped critical and novel ideas into themes. Attendees voted on six themes they prioritized to discuss in a fourth, 120-min session, during which small groups operationalized prioritized actions. Subsequently, all ideas were collated, combined, and revised for clarity by a subset of the authorship team.

Results From this multistep process, 150 actions emerged across 10 priority areas, which together constitute the research agenda. Actions included discrete activities, projects, or products, and ways to shift how research is conducted to strengthen the study of implementation mechanisms.

Conclusions This research agenda elevates actions to guide the selection, design, and evaluation of implementation mechanisms. By delineating recommended actions to address the challenges of studying implementation mechanisms, this research agenda facilitates expanding the field of implementation science, beyond studying what works to how and why strategies work, in what contexts, for whom, and with which interventions.

Keywords Implementation science, Mechanisms, Mediators, Determinants, Implementation strategies, Methods, Measurement, Design, Theory, Causality

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Contributions to the literature

- This research agenda operationalizes a set of activities to strengthen the implementation science field's focus on why and how strategies work.
- The research agenda addresses the following activities: accumulating knowledge, innovating methods and overcoming design challenges, improving measurement, providing guidance for specifying causal mechanisms, increasing focus on theorizing, engaging the policy and practice community, engaging funders, building capacity, enhancing equity, and effectively disseminating methods.
- Studying implementation mechanisms can promote pragmatic strategy development, equitable processes and outcomes, and policy relevance by clarifying pathways for overcoming contextually specific barriers and achieving outcomes of interest.

Background

Some see implementation science as not just *a* pathway, but *the* pathway for advancing equity in healthcare access and outcomes, and equitable population health [1]. Although this research pathway can lead to equity, it is certainly not guaranteed, and in fact, like many fields, most implementation science theories, models, and frameworks did not center equity until recently [2]. This omission leaves implementation studies and strategies vulnerable to unintended consequences (or ripple effects) that might actually exacerbate disparities [3, 4]. The field of implementation science has made significant progress in this regard. Scholars like Woodward et al. [5] offer practical guidance for incorporating health equity domains into implementation determinant frameworks, and Gaias et al. [6] proposed a process to evaluate and adapt implementation strategies to promote equity. Walsh-Bailey is developing a resource to guide the integration of equity into strategy selection, design, and specification [7]. Moreover, numerous efforts collocate factors that enable or obstruct the implementation of evidence-based interventions [8–10], and compile behavior change techniques and implementation strategies that may modify these factors [11–16]. Even with these advances, little research sheds light on *how or why* strategies work, in what contexts, and for whom [17–21]. Studying implementation mechanisms, or the processes through which strategies exert their effects on outcomes, can address this research gap to meaningfully advance the field of implementation science and enhance its value in facilitating equitable policy and practice change.

Mechanistic implementation research can identify potential mediators or moderators that illuminate differential strategy impact based on factors such as gender, race/ethnicity, socioeconomic status, and center on understanding equitable approaches to implementation science and practice.

One of the principles of implementation science is that *context matters*, and by nature, each context is unique. The people, their interactions, their physical environment and resources, and their history and beliefs about the future, are among the subset of aspects that are diverse among clinics in the same organization, schools in the same district, and hospitals in the same health system. As implementation science evolves, complex and costly strategies are increasingly being deployed, making equity issues especially pronounced for those receiving care in under-resourced settings [20]. Evidence suggests that tailored implementation may be superior to standardized approaches [22, 23], but tailoring in the absence of understanding strategy mechanisms may compromise outcomes for some or undermine scaling positive outcomes. Establishing strategy mechanisms of action means that the essence of how a strategy works is known and empirically supported. Therefore, when tailoring, adapting, or modifying to fit different contexts, the essence of the strategy's operation can be retained. When strategies are streamlined to fit contextual constraints or adapted to be a better fit, the mechanism ought to be activated if we are to expect the same outcome. Conversely, if strategies underperform or fail to work in certain settings, unpacking the causal pathway can lead to isolation of contextual factors that threaten mechanism activation or demand a new mechanism altogether. This is not to say that simply studying mechanisms will guarantee equitable outcomes, but in studying them, equitable implementation processes and outcomes are more likely.

To this end, in 2017, the Society for Implementation Research Collaboration (SIRC) conference theme centered implementation mechanisms to elevate dialogue and research about, "What Makes Implementation Work and Why?" [24]. SIRC is a not-for-profit society that convenes scholars, practitioners, policy makers, and others interested in advancing rigorous evaluation of implementation initiatives. SIRC's call to action was motivated by the observation across trials that heterogeneity is the rule, not the exception, and weak main effects result. Thus, advancing the study of implementation mechanisms may offer benefits to research and practice communities. For example, identifying and evaluating mechanisms can help researchers learn from null studies [17] and optimize

strategies for subsequent efforts or different objectives (e.g., equity, effectiveness, scalability) [25]. Articulating mechanisms can guide the practice community to identify the impact that strategies might have on their outcomes and inform their design or tailoring of strategies to the local context [26, 27]. Despite this call, only 7% of abstracts included at the subsequent (2019) SIRC conference [28] explicitly “featured the study of implementation mechanisms” [29].

In response to this need to advance the study of mechanisms, we convened an Agency for Healthcare Research and Quality-funded 3-year conference series titled, “Advancing mechanisms of implementation to accelerate sustainable evidence-based practice integration” [30]. The specific aims were to (1) develop a research agenda on implementation mechanisms, and (2) disseminate the research agenda to research, policy, and practice audiences. Similar to processes used for generating related research agendas (e.g., sustainability research [31]), concept mapping was employed in the first two years of the grant to elucidate challenges to advancing implementation mechanisms research [30, 32] and to organize these ideas into conceptually distinct clusters. Reported in more detail elsewhere [30, 32], concept mapping analyses yielded a 12-cluster solution that organized 105 challenge statements within five “super clusters” of mechanism research domains: (1) Accumulating Knowledge, (2) Conceptualization and Measurement, (3) Methods and Design, (4) Strategy, Mechanisms, Determinant, Outcome Linkages, and (5) Theory, Causality, and Context. See Table 1 for a complete list of identified challenges organized by cluster. These concept mapping results provided the basis for the research agenda. This paper describes how actions that could overcome those challenges were identified and presents the resulting research agenda.

Method

Mechanisms Network of Expertise (MNoE)

The research agenda was developed by the Mechanisms Network of Expertise (MNoE). The MNoE is composed of over 40 invited implementation scientists who are diverse with respect to several dimensions (e.g., gender, race/ethnicity, stage of career, focus on priority populations, research settings), but who are predominantly United States (US)-based (4 scholars are from outside the US); See Additional File 1. Expertise ranged across various aspects of implementation mechanism research including strategy development, measurement, design, theory, and practice. We gathered collective wisdom and engaged in reciprocal learning with these experts through immersive, multi-day “Deep Dive” meetings.

Identifying research priorities via nominal group technique: MNoE data generation

A US-based¹ subset of the MNoE ($N=23$) met in person for a 3-day Deep Dive to address two goals: 1) expand upon the challenges derived from the previously completed concept mapping, and 2) generate ideas or actions (hereafter just referred to as *actions*) organized by priority areas, which constitute the research agenda, to advance the study of implementation mechanisms. To this end, attendees received handouts with the cluster solution from concept mapping and the list of statements associated with each cluster (Table 1). These two goals were pursued through four, 120-min sessions comprised of a 75-min small-group activity followed by a 45-min large-group activity. (Table 2) Group activities were structured using evidence-informed, semi-structured group problem solving activities—called “scripts”—derived from operations, consulting, and systems science methods [33, 34] (Table 3). Scripts include discussion prompts, guidelines about how time is spent (e.g., in small versus large groups), roles to be assumed by individuals (e.g., timekeeper), and session goals (e.g., brainstorming actions for a given cluster). A core planning team ($n=5$) selected scripts from a repository and tailored them to Deep Dive objectives (e.g., identifying actions for addressing challenges to studying implementation mechanisms) across the sessions. Tailoring of scripts included adjusting the time allocated for each script, the examples used, and the wording of the prompts. The planning team assigned small group membership beforehand to ensure diverse groups regarding career stage and content or methodological expertise. The small group composition changed by session to stimulate creative conversation and cross-pollinate ideas by hearing new perspectives.

A tailored Nominal Group Technique process was followed for the first three sessions. Instead of first brainstorming individually, as in the traditional Nominal Group Technique [35], small groups first generated action ideas before sharing, discussing, and voting on priority ideas with the large group. Attendees did the following in small groups before converging as a large group (Table 3): 1) *Assign group roles*, including scribe (to record discussion), reporter for large group, and timekeeper. Individuals could assume more than one role. 2) *Brainstorm actions* for inclusion in the research agenda and address the challenges from the five super-clusters (the planning team assigned which super-clusters were discussed during each of these sessions). Actions could include methods, tools, activities, meetings, research products, research foci, disciplines, or people/perspectives to be

¹ MNoE members from other countries were invited, but unable to attend due to COVID restrictions.

Table 1 Concept mapping super-clusters, clusters, and statements

Cluster	Statement
THEORY, CAUSALITY, & CONTEXT	
Insufficient Use of Theory	<p>Not always clear whether to prioritize theory or pragmatic (stakeholder & context) input in defining mechanism</p> <p>Theories, models, and frameworks rarely specify mechanisms</p> <p>Studies of implementation strategies and/or mechanisms are not often informed by theory</p> <p>Studies rarely include explicit theories of change or logic models, and those that do rarely articulate mechanisms</p> <p>Theories and frameworks do not always align with the level of strategies and mechanisms activated</p> <p>Behavior change theories have not been sufficiently applied to identify candidate implementation mechanisms</p> <p>There is not a consistent understanding of causal pathways and templates to promote testing those pathways</p>
Conceptualizing the Causal Chain and the Role of Context	<p>Assessment of context should be linked to the implementation conceptual framework</p> <p>We don't know which mechanisms to prioritize because of lack of information about the malleability of different determinants</p> <p>We have a limited understanding of mechanisms that are generalizable across settings, populations, and interventions</p> <p>We don't understand if and how mechanisms change across cultural context</p> <p>Many conceptual and measurement models of mechanisms do not include an implementation strategy</p> <p>We do not sufficiently clarify the strategy-mechanism-outcome cascade when conceptualizing studies</p> <p>Unclear if mechanisms for implementation and de-implementation differ</p> <p>Given the lack of conceptual clarity and difficulty measuring context, we may not adequately capture context as a moderator</p> <p>Determinants can also be mechanisms depending upon what questions are being asked, which contributes to lack of conceptual clarity and adds complexity</p>
STRATEGY, MECHANISM, DETERMINANT, OUTCOME LINKAGES	
Factors Influencing Strategies, Mechanisms, & Determinants	<p>Unclear how adaptation of implementation strategies affects if or how a mechanism is activated</p> <p>We do not know how stakeholder involvement functions in activating or moderating mechanisms</p> <p>There is often a mismatch between strategies selected and the level (e.g., individual, organizational, etc.) of determinants and mechanisms identified</p> <p>How a strategy is operationalized could affect whether/how a mechanism is activated</p> <p>Complexity in disentangling implementation strategy from intervention and clearly labeling each component makes studying mechanisms challenging</p> <p>We don't have a clear understanding of how implementation strategies exert their effects in different settings</p> <p>Unexpected contextual changes may affect mechanism activation</p> <p>Limited use of systematic methods for strategy selection that include an articulation of how strategies work</p> <p>Not clear which implementation strategies address specific determinants</p>

Table 1 (continued)

Cluster	Statement
Complexity & Multiplexity in the Strategy-Mechanism-Determinant-Outcome Pathway	<p>Mechanisms are difficult to elucidate in complex social phenomenon and may be reductionistic</p> <p>A single mechanism can be addressed by multiple strategies</p> <p>Difficult to prioritize mechanisms to study given the presence of multiple mechanisms</p> <p>Because of methodological and analytic limitations, we tend to over-simplify the complexity of causal pathways</p> <p>Different mechanisms need to be activated at different points of the implementation process</p> <p>Different outcomes might be affected by different mechanisms</p> <p>It is difficult to detect the interactive effect of strategies on mechanisms and outcomes</p> <p>Multifaceted strategies may have interactive, indirect, or direct effects</p> <p>It is difficult to determine which components of a multifaceted strategy are necessary and sufficient</p> <p>It is unclear which strategies at what dose and time are necessary to activate a mechanism</p> <p>A single strategy can address multiple mechanisms</p> <p>Studying discrete strategies may be necessary but insufficient in delineating mechanisms</p> <p>Mechanisms are difficult to elucidate in complex social phenomenon and may be reductionistic</p>
DESIGNS, METHODS, & MEASUREMENT	
Where to Focus Measure Development & Use	<p>Measures of mechanisms are not harmonized across studies</p> <p>There is an overemphasis on mechanisms at the intra-personal level</p> <p>Lack of high-quality, brief, pragmatic measures of mechanisms</p> <p>Lack of measures to assess all factors in a causal pathways</p> <p>Limited guidance for selecting measures to assess mechanisms</p> <p>Systems-level mechanisms missing from studies</p>
Time as it Relates to Design & Measurement	<p>Implementation science rarely considers client/patient-level mechanisms</p> <p>Typically not feasible to directly manipulate implementation strategies to activate mediators</p> <p>Measuring a mechanism may have an impact on the mechanism itself</p> <p>Measurement and analysis of mechanisms across sites may be hampered by differential rates of change</p> <p>Cannot establish a mechanism without carefully timing measurement</p> <p>Unclear how often we need to measure mechanisms</p> <p>Tension between precision testing of mechanisms and allowing for broader assessment of multiple mechanisms at multiple time points</p> <p>Unclear how to best study emergent mechanisms vs. those hypothesized at the onset of a study</p> <p>May be measuring mechanisms/outcomes too soon to determine if the mechanism was successfully activated</p> <p>Methods for tracking strategies are insufficient for analyzing multiple mechanisms and change in mechanisms over time</p> <p>It is difficult to measure mechanism activation</p>

Table 1 (continued)

Cluster	Statement
Methods & Design Opportunities	<p>Assessment of time component is often missing from qualitative studies</p> <p>Methods such as random assignment to all possible combinations of implementation strategies are not feasible</p> <p>Qualitative methods not sufficient for establishing evidence for a mechanism</p> <p>Underuse of qualitative and mixed methods approaches for studying mechanisms</p> <p>Too much reliance on self-report measures</p> <p>Study of mechanisms limited mostly to earlier phases of the implementation process, and there is less understanding of later stages</p> <p>Cross-sectional measurement insufficient to fully establish or confirm mechanisms</p> <p>Current methods are challenging or insufficient for analyzing multiple mechanisms and change in mechanisms over time</p> <p>Many implementation studies are not sufficiently powered to examine multi-level mechanisms</p> <p>Lack of multi-level mediator assessment</p> <p>Observational longitudinal studies are not sufficient to establish a mechanism</p> <p>Underutilization of rapid ethnographic methods and other real-time data collection methods for studying mechanisms</p> <p>Underuse of observational designs for studying mechanisms</p> <p>Lack of prospective study designs to study mechanisms</p> <p>Commonly used study designs are not well-suited to studying mechanisms</p> <p>Conducting experimental studies to establish mechanisms using best practices is costly</p> <p>Pragmatic, stakeholder-engaged study designs are underutilized in the study of mechanisms</p> <p>Tightly controlled studies to examine hypothesized strategies and mechanisms are lacking</p>
Overreliance on Problematic or Insufficient Methods	<p>Rarely is the study of mechanisms a primary study aim</p> <p>Studies of mechanisms are of variable quality and there are few high-quality studies</p> <p>We have few studies that examine implementation mechanisms, and those that do focus on a narrow range of strategies or mechanisms</p> <p>Most studies do not assess mediators in the same way, which makes it difficult to compare across studies</p> <p>Difficult to balance gathering sufficient data to study mechanisms and participant/researcher burden</p>
ACCUMULATING KNOWLEDGE	
Prioritizing Mechanism Research and Incorporating Other Knowledge	<p>It is difficult to balance the need for rapid knowledge generation and having a methodical approach to building evidence over time</p> <p>Mechanisms are not systematically or consistently assessed across studies</p> <p>Not fully capitalizing on systems science approaches to study mechanisms</p> <p>Lack of incorporation of findings from pilot studies into conceptualizing mechanisms</p> <p>We rarely include the perspectives of clients/patients when studying mechanisms</p> <p>We are not leveraging/combining datasets to study mechanisms</p>

Table 1 (continued)

Cluster	Statement
Accumulating Knowledge Within & Across Disciplines	<p>Poor reporting limits our understanding of mechanisms</p> <p>No central location to collate learning across studies</p> <p>Field lacks foundational training in mechanistic research</p> <p>Funding agencies may not recognize the need for research that focuses on mechanisms</p> <p>The study of mechanisms is approached from many different disciplines, making it difficult to have a set of cohesive methods and designs</p> <p>Do not have rapid, systematic ways of learning from available literature to inform study of mechanisms</p> <p>Not enough reliance on previous studies to identify mechanisms</p> <p>Not adequately capitalizing on other fields that have advanced the study of mechanisms</p> <p>By focusing on mechanisms, we risk minimizing the importance of health and public health outcomes</p>
CONCEPTUALIZATION & MEASUREMENT	
Nomenclature and Associated Resources	<p>Researchers' assumptions may interfere with consideration/selection of appropriate mechanisms</p> <p>Lack of clearly defined roles (researchers, practitioners) and relationships between roles in studying mechanisms</p> <p>Lack of common language and precise and distinct terms for mechanisms within implementation science</p> <p>The field lacks a list of mechanisms</p> <p>There is little attention paid to the criteria for establishing mechanisms</p> <p>Limited guidance on how to specify and report mechanisms</p> <p>Confusion among the terms mechanism, mediator, and moderator</p> <p>Lack of common language for mechanisms across fields</p> <p>Language for studying mechanisms is rife with jargon, which does not allow for clear communication with frontline staff and other relevant stakeholders, hindering incorporation of their perspectives</p> <p>Funders lack clear expectations and common language regarding the study of implementation mechanisms</p>
Conceptual & Empirical Ambiguity	<p>Active ingredients, core functions, and mechanisms are conceptually related, but distinct, and they are rarely sufficiently operationalized and measured</p> <p>Difficult to determine which mechanisms to prioritize due to lack of evidence on the strength of various mechanisms</p> <p>Studies do not always explicitly link causal theory to measurement</p>

engaged. 3) *Prioritize two actions for full group discussion*: based on consensus, one idea favored by the group and one idea that was complex, underdeveloped, or surprising to work through were selected. Small groups were encouraged to spend approximately 60 min brainstorming and 15 min prioritizing actions. Each prioritized action was submitted on paper for sharing in the large group session. Groups were encouraged to write as many actions as they could generate. Scribes' notes were later analyzed (see below). All actions generated, not just those prioritized for deeper discussion, were considered in developing the research agenda.

During the first three large-group discussions, each group's reporter briefly described how their two prioritized actions would advance the study of implementation mechanisms. Each group had 5 min to share and take questions. Simultaneous with sharing out, facilitators collected the papers and grouped similar actions on a wall visible to all. After all small groups shared, the facilitator summarized the action themes. The large group collectively reflected on these and used the remaining time to further develop prioritized actions.

The fourth (final) session synthesized and expanded actions brought forth in the preceding sessions. Each

Table 2 Clusters reviewed during deep dive sessions

Session #	Super-cluster	Clusters included
1	<ul style="list-style-type: none"> • Theory, Causality, Context • Strategy, Mechanism, Determinant, Outcome, Linkages 	<ul style="list-style-type: none"> • Insufficient use of theory • Conceptualizing the causal chain and role of context • Factors influencing strategies, mechanisms, and determinants • Complexity and multiplexity in the strategy mechanism-determinant-outcome pathway
2	<ul style="list-style-type: none"> • Accumulating Knowledge • Conceptualization & Measurement 	<ul style="list-style-type: none"> • Accumulating knowledge within and across disciplines • Prioritizing mechanism research and incorporating other knowledge • Nomenclature and associated resources • Conceptual and empirical ambiguity • Where to focus measure development and use
3	<ul style="list-style-type: none"> • Methods & Design 	<ul style="list-style-type: none"> • Time as it relates to design and measurement • Over-reliance on problematic or insufficient methods • Methods and design opportunities
4	<ul style="list-style-type: none"> • All 	<ul style="list-style-type: none"> • All

attendee used five votes to indicate preferred actions (or group of actions) [36]. The highest-voted actions ($n=6$) were prioritized for this session. Attendees self-selected into small groups based on which prioritized actions they wanted to discuss. During the final large-group session, each group shared how the actions had evolved or whether new actions emerged. One facilitator synthesized actions and asked clarifying questions, while another captured actions and priorities on large pieces of paper for the large group to see and discuss.

Data extraction and consolidation

To populate the research agenda, a subgroup ($N=6$) of attendees extracted data from notes taken across the Deep Dive. Please refer to Table 4 for terms (and definitions) used to organize the research agenda. All unique actions were extracted from each session note that covered at least one super-cluster. Each session note was assigned a primary and a secondary coder. Coders met monthly as a group to refine the process and discuss emergent content. The primary coder extracted action data and refined the language to represent a succinct, coherent action based on: (1) the content of the notes, (2) the context of the larger discussion in the notes, (3) discussion with colleagues (during and/or after the Deep Dive), and (4) consideration of the broader literature. The secondary coder checked data accuracy, separated or grouped actions to ensure each reflected a singular activity, and refined the action verbiage. Coders were encouraged to interpret data to generate additional actions. Coders then worked across sessions to clarify and condense the list of actions, reduce redundancy, and organize actions into priority areas (“priorities”). Given the number of actions identified for each priority area, it became clear that organizing actions within priorities by goals could offer a useful, high-level summary.

Coders reviewed all actions in a priority and articulated 2–4 goals that could be achievable by a subset of actions. Each action was then labeled with its corresponding goal. Lastly, the first author synthesized all actions and associated goals within each priority, solicited input from the full authorship team, and refined the data to yield the final research agenda.

Results

Table 5 presents the refined list of the MNoE-generated actions, organized by priorities and goals, into a research agenda to advance the study of implementation mechanisms. Although not required per our method, priorities reflected all five super-clusters from the concept mapping solution. In addition, priorities emerged specific to *Engagement* (of policy and practice communities, as well as funders) and *Growing the Field* in terms of capacity (number of knowledgeable researchers) and skills specific to studying mechanisms. The MNoE generated 150 unique actions across 10 priority areas (range: 11–19 actions per area). These actions included a mix of discrete activities, projects, or products, as well as ways to shift how research is conducted to center implementation mechanisms. Wherever possible, citations are included in the table to offer exemplars that represent the intention behind the possibility.

Here, we briefly describe each priority and the types of associated actions. Table 5 presents additional details—including goals that each priority area might achieve. The first set of actions are directly aligned with the concept mapping solution super-clusters.

- *Accumulate Knowledge within and Across Disciplines* includes 19 actions that feature specific systematic reviews and meta-analyses, for example,

Table 3 Group model building “scripts”

Script	Script Purpose (Tailored for MNoE Deep Dive)	Activity	Session(s) used	Length
Action Ideas	“Identify action ideas (solutions, possibilities, priorities) for addressing the challenges and opportunities in each concept mapping cluster.”	<p>Similar to Nominal Group Technique procedures, action ideas were first identified within small groups. A notetaker wrote one idea per piece of 8.5” x 11” paper. This allowed each idea to be visually displayed and clustered with like ideas in the large group session. For each action idea, groups were asked to consider:</p> <ul style="list-style-type: none"> • <u>Who</u> might be responsible for fulfilling this action? • <u>How</u> might it be achieved? • <u>How long</u> might it take to realize this action idea? (e.g., 1 project over a year, multiple projects over 5 years, etc.) <p>During the large group session, a facilitator asked groups to share one complex idea that might require group discussion and one favorite idea <i>per concept mapping super cluster</i> for a total of 2–4 ideas. Participants were asked to “briefly describe the idea and how it would advance the study of mechanisms and IS.” Other groups had the opportunity to ask questions about the shared action idea or express if they had a similar idea. The order in which small groups were asked to share was varied across each large group session. A person assigned the role of “wall builder” identified themes among ideas and clustered ideas on the wall as they were shared out. Ideas that were not shared were clustered after the small group finished sharing their priority ideas. The wall-builder reflected on these themes after all small groups shared, and invited corrections or suggestions</p>	Sessions 1–3	75 min (Small Group) 45 min (Large Group)
Dots	Identify action ideas of priority to discuss during final small group and large group session	<p>Each participant received 5 stickers to vote on action ideas from earlier sessions. Participants could vote on a specific action idea or on a cluster of ideas by placing the sticker on the small piece of paper (action ideas) or large pieces of paper labeled with action idea themes (idea clusters). Participants voted simultaneously and could put multiple stickers on a single action idea or cluster</p> <p>The action ideas and clusters with the highest votes (i.e., dots) were identified by facilitators. The large group briefly met to identify: a) whether the prioritized action ideas and clusters could be further clustered to allow for efficient discussion of as many prioritized ideas as possible, and b) who would participate in each small group</p>	Immediately prior to final small group (Session 4)	20 min (10 min voting, 10 min group discussion and organization)

Text in quotes was explicitly stated to participants

Table 4 Terms and Definitions

Term	Definition
Implementation mechanisms	Mechanisms are the processes responsible for change. In this research agenda, implementation mechanisms refer to mechanisms of implementation strategy operations. This term is used interchangeably with “mechanisms of action.”
Research Agenda	A research agenda provides a framework or map for advancing a topic, including actions that can be taken [37]
Deep Dive	This term represents an immersive retreat that brought together the Mechanisms Network of Expertise to identify research priorities via modified nominal group technique and group model building
Cluster	This term refers to a group of items/statements that are grouped together in concept mapping via multivariate statistical techniques including multidimensional scaling and cluster analysis [38]
Super Cluster	This term refers to a group of clusters that are conceptually related
Theme	This term refers to conceptually related actions that organically emerged among the actions in the Deep Dive
Action	This term refers to discrete ideas, activities, projects, or products, and ways to shift how research is conducted to strengthen the study of implementation mechanisms. These are the discrete elements within the Research Agenda
Priority	This term (also referred to as “priority area”) reflects a group of actions that are conceptually related and unique from other priority areas within the Research Agenda
Goal	This term refers to an outcome that could come about should related actions be executed in the Research Agenda

and research questions that would drive this type of evidence synthesis (e.g., determine whether mechanisms are universal, or if variation across contexts is observed).

- *Prioritize Mechanism Research and Incorporate Other Knowledge* includes 11 actions that would bring together transdisciplinary teams across fields where mechanisms are likely a prominent area of research, such as psychology and epidemiology.
- *Overcome Design Challenges and Innovate Methods* includes 18 actions where new methods are needed (e.g., modeling time in quantitative assessment to isolate specific mechanisms) and identifies under-used methods offering specific value (e.g., comparative case studies to generate hypotheses about complex mechanistic pathways).
- *Improve Measurement* includes 13 actions, such as pragmatic approaches for objective data collection and those that capture lived experiences—an essential measurement component to understand when disparities might be addressed or exacerbated through implementation research and practice.
- *Provide Guidance for Specifying Mechanisms* includes 15 actions reflecting mostly tools/aids to improve researchers’ approach to examining mechanisms (e.g., a list of questions and criteria for articulating mechanisms).
- *Increase Focus on Theorizing* includes 12 ways to capitalize on developing, incorporating, and refining theory into mechanistic research to better characterize mechanisms (e.g., make theory explicit in the strategy design phase).
- *Engaging the Policy and Practice Community* includes 12 actions or methods for understanding the perspective of these potential partners (e.g., cognitive walkthroughs, plain language, Implementation Mapping [64, 65]) and questions about when to include whom and how (e.g., compare “ground up” elucidation of mechanisms to the “top down” or theory-driven approach).
- *Engaging Funders and the Need for New Funding* includes 17 actions to garner interest and expertise (e.g., mock study sections) and inspire novel use of new grant mechanisms (e.g., administrative supplements, trainee funding mechanisms).
- *Build Capacity* includes 17 actions to offer clarification/guidance (e.g., how to understand conceptual/theoretical misalignment between strategies, mechanisms, and outcomes) and avenues to build the field’s capacity (e.g., postdoctoral training grants).
- *Emphasize Dissemination* includes 17 actions like specific manuscript ideas, ways to engage journals to support mechanism-focused manuscripts, forums to host this dialogue, and other methods for generating broader interest beyond academia. Such methods are intended to foster iterative and collaborative advancements in mechanism research across interdisciplinary groups.

Discussion

This paper articulates opportunities to advance the study of implementation mechanisms in a research agenda organized by priorities for the field and specific actions to advance those priorities. Actions range from those that can be acted upon now by way of shifting the research paradigm (e.g., always articulate mechanisms when designing implementation strategies) to those that may

The emergent actions related to *Engagement* and *Growing the Field* provide further priorities for action.

Table 5 Research agenda to advance the study of implementation mechanisms

Priority & Goals	Actions
<p>Accumulating Knowledge</p> <p>Accumulate Knowledge within and across Disciplines (N = 19)</p> <p>Goal 1: Synthesize existing knowledge from completed studies</p> <p>Goal 2: Coordinate conduct of ongoing and future studies</p>	<p>(1.1) Conduct a systematic review of how implementation strategies are operationalized and associated putative mechanisms [39]</p> <p>(1.2) Conduct systematic or integrative reviews of discrete implementation strategies with a focus on mechanism articulation or activation and factors influencing equitable impact [40–42]</p> <p>(1.3) Conduct a meta-analysis of mechanisms to explore effect sizes [43]</p> <p>(1.4) Develop a case series of completed studies that use the same analytic strategy to examine mechanisms; explore relevant issues (e.g., measurement, implementation fidelity [44–46]; cultural relevance)</p> <p>(1.5) Test discrete implementation strategies in diverse contexts while assessing mechanisms for confirmation/replication, or manipulate the same mechanisms in different settings to test the variation in activation toward generalizability [47]</p> <p>(1.6) Empirically examine how context, and specifically cultural context, influence mechanism activation to ascertain if different mechanisms are needed for activation</p> <p>(1.7) Determine whether strategy-mechanism pairings are universal, or if pathways vary across contexts (e.g., service system, community) and how strategy operationalization occurs (i.e., form versus function)</p> <p>(1.8) Determine which implementation strategies are needed for specific types of interventions (e.g., practice & feedback needed for psychotherapy implementation) similarly across contexts</p> <p>(1.9) Triangulate across studies to curate and prioritize mechanisms that are most potent in resolving certain barriers including those preventing equitable access to care</p> <p>(1.10) Consolidate examples of strategy-barrier mismatches and highlight alternative pairings</p> <p>(1.11) Synthesize knowledge of putative mechanisms across studies using qualitative methods [48]</p> <p>(1.12) Synthesize knowledge of which strategies have evidence of resolving specific determinants across diverse operationalizations</p> <p>(2.1) Identify factors that affect mechanisms and their activation (e.g., context, level of analysis/where in the pathway we are focusing, degree of mutability)</p> <p>(2.2) Generate a mechanism-focused study repository to enable sharing of information: share measures of mechanisms; report impact/effect of strategies focusing on <i>how</i> and <i>why</i>; provide exemplar studies across a range of study designs and contexts, especially those that engage community/practice partners from diverse groups</p> <p>(2.3) Create meta-labs [33] for widely used implementation strategies to pool samples for mediation analysis; strategies to examine might include audit and feedback [34]; learning collaboratives, and practice facilitation</p> <p>(2.4) Gather observational data across a large number of studies for simulation model development to inform what to focus on for measurement and how to measure</p> <p>(2.5) Conduct more simulation studies to understand how multifaceted strategies exert their effects</p> <p>(2.6) Examine behavior change principles in different contexts and uncover variability in predictive validity [49]</p> <p>(2.7) Demonstrate how implementation mechanisms drive public health benefits by resolving barriers and realizing implementation outcomes</p>

Table 5 (continued)

Priority & Goals	Actions
<p>Prioritize Mechanism Research & Incorporate Other Knowledge (N = 11)</p> <p>Goal 3: Draw on approaches taken by other disciplines</p> <p>Goal 4: Collaborate with experts from other disciplines</p>	<p>(3.1) Consider the following fields for their definitions and their specific approaches to studying mechanisms (list is non-exhaustive):</p> <ul style="list-style-type: none"> • Behavioral psychology – principles of learning and behavior change • Clinical psychology – case conceptualization • Engineering – practical language of inquiry • Epidemiology – directed acyclic graphs • Medical anthropology – ethnographic methods • Systems science – network simulation [50] • Marketing – communicating complex phenomenon • Systems engineering – design, integrate, and manage complex systems • Ecosystems science – complex systems with dynamic contexts • Political science—process tracing, agent-based modeling <p>(3.2) Look across disciplines to fields in which one entity helps another do something differently to understand how they explore mechanisms (e.g., governance, natural resources, education), including their approaches to pursuing equity</p> <p>(3.3) Bring in methods from multiple disciplines for articulating and representing mechanisms (e.g., directed acyclic graphs (DAGs) [17], causal pies, quality improvement 5 why's, root cause analysis, user story mapping, logic model, key driver diagrams, and other methods for depicting mechanisms visually [51])^a</p> <p>(3.4) Acknowledge that systems science might clarify where the biggest opportunities for change exist; Make clear for what purpose (good for multi-level models, can inform pragmatic decisions, can identify moderators) and the limitations of these methods (curse of dimensionality)</p> <p>(4.1) Convene a multidisciplinary group (e.g., a CTSA workgroup on advancing implementation mechanisms) to identify similar concepts and complementary methods, and accumulate knowledge</p> <p>(4.2) Conduct mechanisms-focused workshops led by experts from adjacent/different fields to introduce “new” ways to study mechanisms in implementation science</p> <p>(4.3) Create affinity group for people who are using systems science and complexity theory methods such as agent-based modeling, system dynamics, and social network analysis</p> <p>(4.4) Model a conference/workshop after the Veteran Affairs State-of-the-Art (SOTA) conference that develops research priorities by engaging multidisciplinary teams</p> <p>(4.5) Engage mechanism experts from peripheral disciplines as partners in research</p> <p>(4.6) Host a “hackathon” or Shark Tank with teams working on same problems using the same data to surface novel understandings about mechanisms</p> <p>(4.7) Develop 1-page documents to introduce to implementation science to different fields where mechanisms are a strong focus and inspire bi-directional learning</p>
<p>Methods & Design</p> <p>Overcome design challenges & Innovate methods (N = 18)</p> <p>Goal 5: Guide selection and refinement of study designs</p> <p>Goal 6: Enable measurement of pertinent and feasible data</p> <p>Goal 7: Leverage strengths of different research methods</p>	<p>(5.1) Surface range of designs (build a compendium), their trade-offs [52–55], and offer guidance for which to use when depending on research question, stage of implementation, readiness/resources of the context, including: Agent-based modeling [56], pragmatic trials, QI/PDSA, micro-randomized trials, AB designs, single case experimental designs, SMART design, coincidence analysis, QCA, constant comparison analysis^a</p> <p>(5.2) Generate design guidance to center mechanisms in complex contexts & long causal chains</p> <p>(5.3) Emphasize how SMART designs should center the study of mechanisms</p> <p>(5.4) Simplify the causal chain from implementation strategies to outcomes to promote harmony in design and synthesis across studies</p> <p>(5.5) Employ comparative case study designs using qualitative or ethnographic methods to create hypotheses about complex pathways</p> <p>(5.6) Offer benchmarks for meaningful effect sizes for strategy-mechanism-outcome pathways</p> <p>(6.1) Generate tools to help model direct and indirect effects, and systematic evaluation of mechanisms</p>

Table 5 (continued)

Priority & Goals	Actions
Conceptualization & Measurement	<p>(6.2) Generate a methods paper that elucidates what data (e.g., emails, team process meeting notes) and approaches can support the study and analysis of mechanisms across diverse contexts [57]</p> <p>(6.3) Prioritize testing for signal (i.e., early indicator offering a sign that something is/is not working) in shorter time frames with reasonable level of evidence [58]</p> <p>(6.4) Articulate hypothesized and, eventually, empirical “go/no-go” indicators of mechanism activation based on theory-informed hypotheses</p> <p>(6.5) Promote study of intermediate outcomes (i.e., outcomes more proximal to the implementation strategy than implementation outcomes)^a</p> <p>(6.6) Overcome limitations of quantitative assessment of relevant factors to better account for time or when change occurs</p> <p>(6.7) Track contextual changes and document interdependencies between strategy, context, and outcomes to isolate mechanisms</p> <p>(7.1) Establish when qualitative inquiry is needed for surfacing mechanisms versus quantitative “activation” evaluation [59]</p> <p>(7.2) Leverage qualitative inquiry in a formative manner to understand why something did or did not work (i.e., explore mechanisms) and confer with relevant theory; consider issues related to structural racism and inequities in service access, for example</p> <p>(7.3) Conduct qualitative work focused on implementation mechanism hypothesis generation by surfacing the lived experience of diverse community partners</p> <p>(7.4) Conduct powered, multilevel tests of mechanisms if initial studies provide signal of impact</p> <p>(7.5) Overcome the limitations of frequentist statistical methods by leveraging Bayesian methods, practical significance standards</p>
Improve Measurement (N = 13)	<p>(8.1) Align measures to implementation science-relevant elements of the Theoretical Domains Framework and Behavior Change Wheel, for example</p> <p>(8.2) Develop brief measures that allow for repeated, real-time assessment of changes in mechanisms</p> <p>(8.3) Use culturally responsive measures that are mechanism-specific but generalizable across multiple studies</p> <p>(9.1) Employ methods less prone to reporter bias (e.g., ethnography/observation, secondary reporters) and to measurement bias (e.g., objective data capture)</p> <p>(9.2) Generate passive data collection approaches for continuous monitoring of mechanisms</p> <p>(9.3) Utilize ecological momentary assessment [60] or low-burden near-continuous assessments</p> <p>(9.4) Design robust data capture systems to identify unanticipated mechanisms with a focus on diverse populations and contexts</p> <p>(9.5) Elucidate and measure proximal outcomes, as mechanisms are difficult to assess directly</p> <p>(10.1) Build a living repository of measures that are consistently used across studies, tagging each measure for its relevance to strategies, levels, settings, frameworks/theories, etc</p> <p>(10.2) Offer guidance for measurement across multiple levels of analysis and varying timepoints of change</p> <p>(10.3) Clarify mechanisms that can be measured directly versus via proximal outcomes</p> <p>(10.4) Identify mechanisms (at multiple levels) for which we do or do not yet have measures</p> <p>(10.5) Work through measurement issues across teams in a meeting series</p>

Table 5 (continued)

Priority & Goals	Actions
<p>Strategy, Mechanism, Determinant, Outcome Linkages</p> <p>Provide guidance for specifying mechanisms (N = 15)</p> <p>Goal 11: Determine definitions and reporting standards</p> <p>Goal 12: Employ cross-context and multi-level approaches</p>	<p>(11.1) Generate an initial repository of putative mechanisms and implementation strategies with an emphasis on the critical need for it to be continuously updated with emerging evidence^a</p> <p>(11.2) Build out the ERIC compilation to link strategies to determinants via mechanisms^a</p> <p>(11.3) Establish a list of questions and associated criteria to derive/articulate mechanisms^a</p> <p>(11.4) Develop clear, field-specific criteria for establishing implementation mechanisms</p> <p>(11.5) Examine A Guideline for Reporting Mediation Analyses of Randomized Trials (AGReMA) guidelines to see if they can be enhanced to support the reporting of implementation mechanisms</p> <p>(11.6) Produce guidance to ensure validity, equity, and value of implementation mechanism research</p> <p>(12.1) Prioritize precise definitions and simple language decisions to make room for different terms across fields. Within this, differentiate mechanisms (theory of solution) and determinants (theory of the problem) and similarly, the causal mechanism for determinant (why does it exist?) versus causal mechanism of strategy (how does it work?)^a</p> <p>(12.2) Assess mechanisms of fundamental behavioral phenomena that are likely more stable (e.g., improved knowledge after training), and thus may be applicable across very different implementation settings</p> <p>(12.3) Use theory to guide selection of putative mechanisms</p> <p>(12.4) Specify not only whether mechanisms vary by context, but how they might be activated differently across contexts with causal pathway diagrams</p> <p>(12.5) Clarify the benefits and opportunities for prospective versus retrospective mechanism evaluation/analysis</p> <p>(12.6) Consider the relevance of mechanisms at the community or policy levels and how they might support or break down inequitable structures</p> <p>(12.7) Conduct a meta-ethnography of case studies (such as those in organizational literature) to identify common mechanisms that are referred to differently</p> <p>(12.8) Use case-based examples to identify mechanisms, including walking through a story and choices made about mechanism and design along the way and why</p> <p>(12.9) Use the salvage strategy: Walk through an example where implementation failed and explore different decisions</p>
<p>Theory, Causality, & Context</p> <p>Increase Focus on Theorizing (N = 12)</p> <p>Goal 13: Capitalize on opportunities to incorporate theory</p> <p>Goal 14: Provide examples and guidance on incorporating theory</p>	<p>(13.1) Articulate the role of causal theory and program theory in implementation science^a</p> <p>(13.2) Develop/revise extant implementation theories to better represent mechanisms</p> <p>(13.3) Consider whether a single theory spanning individual and organizational levels is relevant and applicable</p> <p>(13.4) Engage a group in reviewing common theories to identify which strategies could realize theoretical impact, including to address structural inequities</p> <p>(13.5) Explore data through theoretical lens, develop or modify theory to explain the data, then test theory with new real-world data</p> <p>(13.6) Making the notion of timing more explicit in the theory of change</p> <p>(13.7) Describe theoretical justification for mechanistic pathway that links back to determinant frameworks (frameworks → theories)</p> <p>(14.1) Make theory explicit by requiring it in the strategy design phase</p> <p>(14.2) Clarify how implementation mechanisms are “theoretical” or how theory is used to articulate mechanisms</p> <p>(14.3) Provide guidance about assessing the quality of theories and best practices for “full” theory integration in implementation</p> <p>(14.4) Prepare guidance for how to choose or develop a theory and how theory complements other forms of knowledge, emphasizing what value theory offers</p> <p>(14.5) Surface examples of theories from other fields (e.g., epidemiology) that include mechanisms</p>

Table 5 (continued)

Priority & Goals	Actions
Engagement	
Engage the Policy & Practice Community (N = 12)	
Goal 15: Engage partners in mechanism identification, validation, and testing	(15.1) Generate a list of questions to assess mechanisms with partners and minimize jargon (e.g., what happened next?) ^a
Goal 16: Use innovative methods to obtain practice-based data and confirm theory	(15.2) Develop clear language so the purpose resonates with practice community partners, and they can contribute their knowledge/perspective
	(15.3) Use plain language [61] when describing, specifying, and measuring mechanisms to help with translation to the practice community and across contexts
	(15.4) Draw from community-partnered participatory research [62], participatory action research, user centered design, group model building, and related methods to develop best practices, methodological examples, and possibly a toolkit for how to engage community partners in elucidating/testing mechanisms
	(15.5) Develop strategies to excite practice partners from diverse communities to study mechanisms
	(15.6) Clarify which community partners can/should contribute to mechanism articulation and testing
	(15.7) Ensure sufficient funding for partners to play an active role in tracking and communicating their “data” about mechanisms [63]
	(15.8) Engage the practice community to obtain feedback on the relevance of implementation mechanisms for their contexts
	(15.9) Engage the practice community in drawing workflows or causal pathways (e.g., using Group Model Building)
	(15.10) Assess practitioners’ experience with why a strategy has worked to inform theorizing and explore generalizability
	(15.11) Honor that partnership engagement may be a mechanism
	(16.1) Partner with diverse community groups for mechanism generation, then explore alignment with theory
	(16.2) Make Implementation Mapping [64, 65] scalable and relevant to non-specialist partners (and/or the practice community)
	(16.3) Consider using cognitive walkthroughs [66] and user-centered design [67] to facilitate clinicians’ sharing of causal information, while being careful not to lead clinicians toward coming up with a cause for their actions when there is no specific cause
	(16.4) Obtain logs from clinicians that describe concerns; receive feedback in small chunks (e.g., clinician centric inbox for implementation feedback); analyze justification data to get at causal relationships (e.g., “this order was placed per practice guidelines” or “this order was recommended by an expert colleague”)
	(16.5) Compare the “ground up” elucidation of mechanisms to the “top down” or theory-driven approach; what do we learn from each?
	(16.6) Articulate processes for integrating empirical and practical knowledge when operationalizing mechanisms
Engage Funders & Need for New Funding (N = 17)	
Goal 17: Make the study of mechanisms a funding priority	(17.1) Create single calls for proposals and/or dedicated funding streams for mechanism-focused research studies or administrative supplements
Goal 18: Grow mechanism expertise among peer reviewers	(17.2) Advocate for prioritizing mechanisms in implementation science focused funding announcements
Goal 19: Create funding models to support mechanism-focused research	(17.3) Ensure ability to study mechanisms and their role in increasing equity is within budget limits; consider de-prioritizing focus on evidence-based intervention impact on patient outcomes when an evidence base is strong
	(17.4) Encourage grant reviewers and funders to prioritize mechanism evaluation in implementation trials
	(17.5) Clarify with policy makers and funders that mechanisms-focused research can lead to a more parsimonious and efficient implementation approach and to reproducibility
	(18.1) Offer an orientation to mechanism-focused research for grant reviewers
	(18.2) Present workshops on mechanisms at implementation science conferences to educate the next generation of reviewers
	(18.3) Conduct mock study section reviews with implementation mechanism researchers
	(18.4) Create guidelines for assessing the rigor of studies intended to examine mechanisms
	(18.5) Host events about mechanism-focused research with program officers as respondents or panel moderators

Table 5 (continued)

Priority & Goals	Actions
	<p>(18.6) Build Board of Experts with national grant funders on implementation mechanisms</p> <p>(18.7) Encourage mechanism-savvy implementation scientists to sit on study sections</p> <p>(19.1) Create grant mechanism in which to test theories and putative mechanisms on a small scale, with the ability to adjust the study/design if the signal is not detected as expected in initial tests</p> <p>(19.2) Prioritize grant funding to pay community partners, fund their time, and incentivize their involvement in mechanism exploration</p> <p>(19.3) Demonstrate for funders the time it takes to engage in ethnography, which is a promising approach to unearthing mechanisms</p> <p>(19.4) Increase project length to create necessary time for deep mechanistic evaluation (could be focus of renewal)</p> <p>(19.5) Fund a coordinating center to integrate findings across numerous studies examining implementation strategy mechanisms</p>
Growing the Field	
Build Capacity (N = 17)	
Goal 20: Build resources for identifying and understanding mechanisms	(20.1) Prepare guidelines or criteria for how to generate or test an implementation strategy causal pathway
Goal 21: Offer trainings on what mechanisms are and how to study them	(20.2) Create guidance/guidelines for how to choose the most appropriate outcome for a given mechanism
	(20.3) Produce guidance surfacing related terms and offer conceptual distinctions
	(20.4) Produce a decision tree, roadmap, or conceptualization tool to ascertain if something is or is not a mechanism
	(20.5) Develop a tool (decision tree, flow chart) for disentangling the intervention from implementation strategies
	(20.6) Clarify how/when to adapt the intervention versus modify the implementation strategy ^a
	(20.7) Clarify ways to unpack how multi-level, multi-component implementation strategies work
	(20.8) Provide guidance on when to change the strategy for the context versus change the context using the strategy based on our understanding of mechanisms
	(20.9) Clarify how to understand misalignment in study findings (e.g., mechanism not activated but outcome achieved, or mechanism activated but no improvement in outcome) and the critical role of context
	(20.10) Clarify how to surface a mismatch or misalignment between strategies and barriers to reveal untargeted or unnecessarily targeted mechanisms
	(20.11) Clarify how to know when tailoring strategies is needed and when changes are extensive enough that a strategy becomes a new strategy with unproven effectiveness
	(20.12) Clarify how to glean generalizable knowledge about mechanisms from quality improvement and case studies
	(21.1) Develop asynchronous trainings on implementation mechanisms (what they are, why they are important, how to study them) ^a
	(21.2) Develop training that teaches people how to specify links in causal chains by creating web-based templates with graphical depictions for how mechanisms relate to implementation problems with instructions (e.g., terms and definitions, questions/prompts)
	(21.3) Train study teams to regularly reflect about why and how an implementation is (or is not) working, including examining equity in the context and/or population
	(21.4) Generate a workgroup to support a series of training grants (e.g., F32s) that study mechanisms
	(21.5) Host a Big Pile of Data Summit; showcase un-utilized data from grants and pair with postdocs with shared mentoring structure

Table 5 (continued)

Priority & Goals	Actions
Emphasize Dissemination (N = 17) Goal 22: Write mechanism-focused manuscripts Goal 23: Partner with journals to promote mechanisms Goal 24: Establish forums for mechanism-focused dialog Goal 25: Generate broader interest in mechanisms	(22.1) Publish annual updates to reviews of implementation mechanisms in implementation science journals (22.2) Publish commentaries in response to studies examining mechanisms to encourage cross-disciplinary/cross-team dialogue (22.3) Write a commentary calling for continuous action, theorizing, and innovating as the study of mechanisms evolves (22.4) Write a paper that describes the non-exhaustive nature of lists (of determinants, for example) and the importance of articulating putative mechanisms ^a (22.5) Write a "Mechanisms Made Too Simple" paper ^a (22.6) Create an Implementation Mechanisms 101 reference document (22.7) Develop a manuscript describing how understanding implementation strategy mechanisms can address health equity by ensuring that strategies are effective in multiple contexts and with multiple populations (23.1) Invite journals to encourage the study of implementation mechanisms (23.2) Develop a new paper type: From Failure to Wisdom (23.3) Create a "Less is More" column in journals that feature the study of mechanisms (23.4) Include call out boxes or columns within papers that feature the story of mechanism activation (24.1) Host multi-day conference with national funders (e.g., National Institutes of Health) that is a publicly streamed event with engaged note takers to develop a consensus statement about the import, implications, and how to study mechanisms (24.2) Host annual pre-conference meetings on implementation mechanisms for several years to share latest developments (25.1) Share examples of how mechanistic research can be used to drive pragmatic decisions: which strategy for whom, when and in what contexts/conditions? (25.2) Clarify why people want to know about mechanisms in promoting the study of mechanisms—develop the "why" with community partners (25.3) Emphasize the benefits to a reductionist approach for science and practice (25.4) Bring communication experts to build capacity for talking across partners about mechanisms

"Actions" refer to discrete actions, ideas, or products. "Priorities" refer to higher-level directions for future research and associated activities. Many actions are relevant to more than 1 priority but are only listed once

^a Indicates actions that are in progress, led by MNoE members coming out of the 2021 Deep Dive. The term "context" is used throughout the table. Context includes key features of the environment in which the work is immersed and which are interpreted as meaningful to the success, failure, and unexpected consequences of the intervention(s), as well as the relationship of these to partners

need targeted funding and specialized knowledge/expertise (e.g., conduct sufficiently powered, multilevel tests of mechanisms with multidisciplinary input). What follows is a discussion of each priority area by highlighting actions (represented by A# corresponding to Table 5) or exemplars organized by goals (represented by G# in Table 5). These actions were articulated by the MNoE (a group of experts) as ways to address challenges identified in their prior concept mapping work.

Accumulating knowledge

With 100+ discrete implementation strategies and behavior change techniques from which to choose [12–16], balanced with evidence that rarely will a single strategy suffice in realizing sustained and robust change [68, 69], accumulating basic knowledge about how strategies work is crucial. Although the MNoE acknowledged that

a starting place could be to curate a list of implementation mechanisms, they also emphasized that there is a risk in overreliance on static lists and frameworks at the expense of theorizing or broader critical thinking [70, 71] (A22.4), particularly where evidence for strategy functioning and causal processes is thin. To this end, the MNoE prioritized knowledge synthesis across completed studies (G1) and coordination of future studies (G2). Specifically, the MNoE prioritized accumulating knowledge to yield practical information such as: (i) which strategies are needed for specific types of interventions across most contexts (e.g., 'practice & feedback' needed for evidence-based psychotherapy implementation) (A1.8); (ii) which strategies hold promise in addressing certain barriers across diverse operationalizations [72, 73] (A1.12) (e.g., educational training to address knowledge deficits); (iii) whether strategy-mechanism pairings are universal, or if

and how pathways vary across contexts (e.g., service system, level of actor, community, culture) or strategy operationalization (i.e., form versus function [74, 75]) (A1.7).

Not only are individual studies needed to test strategy pathways to yield this information (P1.5), which could be done in practical and efficient simulation studies (A2.5), but evidence syntheses are needed to curate this practical information (A1.1, 1.2, 1.3, 1.6, 1.8, 1.9, 1.10, 1.11, 1.12). These possible actions are ripe for those interested in secondary data analysis. Alternatively, meta-laboratories (meta-labs) [76] offer an approach to testing implementation strategies at scale with the possibility of pooling samples for mediation analyses (A2.3). Meta-labs can harness practical implementation efforts in health systems, for example, where different operationalizations of commonly deployed strategies can be examined using harmonized implementation process, service, and patient-level health outcomes contained in electronic medical records. Grimshaw and colleagues are pioneering the meta-lab by convening subject matter experts to accumulate evidence about audit and feedback [76, 77]. It is unclear whether existing grant funding mechanisms can accommodate the infrastructure necessary for multi-study, global coordination, and data sharing in such efforts (A19.5).

To accumulate knowledge efficiently, the MNoE recommended a mechanism-focused study repository for sharing information, evidence, and methods (A2.2). A repository could be used to share measures of mechanisms for cross-study testing and comparison; report impact/effect of strategies with *how* and *why* data; and provide diverse exemplar studies, especially those that engage community/practice partners. Web-based resources for implementation science are mounting (e.g., measure repositories [78, 79]), but to our knowledge, few living repositories or systematic reviews exist perhaps because they are a relatively novel methodology [80] expedited into action by the COVID-19 pandemic [81, 82].

Finally, the MNoE prioritized drawing on other disciplines (G3) and collaborating with experts from other disciplinary backgrounds (G4), such as scholars who study mechanisms using a multilevel perspective (A3.1). There are dozens of fields in which one entity helps another do something differently (A3.2) (e.g., governance, natural resources, education, health promotion) to integrate evidence-based interventions and strive for equity. The MNoE cautioned against our field 'recreating the methodological wheel,' and underscored the utility of multidisciplinary workgroups (A4.1) and workshops (A4.2). The MNoE prioritized actions to make implementation science more accessible (e.g., 1-page documents such as an SBAR: Situation, Background, Assessment, Recommendation [83] that conveys the importance

of studying implementation mechanisms) to support bidirectional learning and springboard convenings. A recent commentary expressed concern that our field borrows superficially from others when interdisciplinarity or trans-disciplinarity is warranted [20]. Funders have recently made deep interdisciplinary collaboration a priority through opportunities such as the National Cancer Institute Implementation Science Centers [84] in which their Research Program Cores bring together numerous disciplines in a Methods Unit to test, refine, and disseminate new approaches [85] throughout 5-year awards [86].

Methods and design

The MNoE asserted the importance of overcoming design challenges (e.g., multiple multi-level mechanisms) and innovating methods (e.g., to address the time-varying nature of mechanism activation) specific to the study of mechanisms. They prioritized activities to guide selection and refinement of study designs (G5), enable measurement of pertinent and feasible data (G6), and leverage strengths of different research methods (G7) to enable establishing strategy mechanisms. For instance, much like the overview of designs that emerged from an NIH working session in 2014 [52], guidance is needed regarding when to use different designs and methods specifically for the purpose of establishing implementation mechanisms (A5.1). The MNoE suggested mechanism activation may offer an earlier signal along the causal pathway to indicate whether a strategy is working as hypothesized (A6.3). Designing trials for early signal testing demands methodological guidance regarding what constitutes reasonable levels of evidence (go/no-go indicators) (A6.4), how to time mechanism measurement or measure intermediate outcomes (A6.5), and how to pivot if the signal is not detected, particularly in a grant-funded study where adapting/changing the implementation strategy (i.e., independent variable) could be deemed a protocol deviation [58]. Fortunately, methods experts are beginning to apply adaptive trial designs that directly answer this call [87]. The MNoE also acknowledged the power of qualitative methods [88–91] to inform theory development and surface candidate mechanisms (A7.1) and to offer formative evidence for why a strategy did not work as intended (A7.2). The MNoE highlighted that qualitative methods provide richness, unique insights, and critical perspectives of those with lived experience [57, 89–92]. Engagement with diverse partners will yield more specific, contextualized, and experientially-informed hypotheses of how strategies are working (A7.3) that may be more acceptable and appropriate for a given context and innovation compared to researcher-derived hypotheses. For example, a secondary analysis of a large implementation trial of measurement-based

care revealed no significant mediators from the quantitative data but identified important candidate mechanisms from qualitative analyses [93].

Conceptualization and measurement

In general, great strides have been made to enhance the quality, access, and utility of measurement in implementation science through systematic reviews, guidance documents, and web-based repositories [78, 79, 94]. The MNoE prioritized actions specific to studying mechanisms to develop grounded and generalizable measures (G8), recommend best practices regarding measurement (G9), and clarify ongoing measurement challenges (G10). The MNoE articulated the need to deploy measurement methods that allow for multiple, real-time assessments to detect changes that unfold over time (A8.2), as mechanisms are hypothesized to be activated at varying rates by population and context. The MNoE elevated the possible use of passive data collection approaches for continuous monitoring of mechanisms (A9.2), ecological momentary assessment (EMA), or lower-burden, near-continuous assessments to track changes in mechanisms and determinants (A9.3). As an example, EMA was used to identify predictors of noncompliance of event-based reporting of tobacco use [95]. Although this example is implementation-adjacent, it reveals how underused approaches like EMA can overcome measurement challenges critical to studying mechanisms such as timing (e.g., multiple, repeated measures) and self-report (e.g., bias, memory).

Strategy, mechanism, determinant, outcome linkages

The MNoE was initially organized to include a subset of scholars who focused on understanding the linkages between strategies, mechanisms, determinants, and outcomes [30]. Recognizing that strategies are too often disconnected from determinants [96, 97] and overpromising outcomes [69], the MNoE articulated the role of mechanisms in the causal pathway in terms of how a strategy exerts its effects on target outcomes by overcoming barriers [98]. The MNoE prioritized defining mechanisms as distinct from determinants and establishing reporting standards for mechanisms research (G11) to support deployment of cross-context and multilevel approaches (G12). The MNoE remarked on this as critical “foundational work” for scientific and practical progress to be made. For instance, the MNoE encouraged consideration of which strategies (from compilations such as Expert Recommendations for Implementing Change (ERIC) [13] and Effective Practice and Organization of Care (EPOC) [99]) have evidence of activating specific mechanisms to resolve particular barriers and achieve specific outcomes. Such foundational knowledge of discrete strategies would be instrumental in designing a practical implementation

plan, but no synthesis or repository exists to our knowledge (A11.1), although a 2016 review does offer preliminary evidence on a subset of strategy-mediator pairings [21]. One activity to contribute this knowledge may be the “salvage strategy” [100, 101] in which journals or conferences feature implementation failures and invite exploration of mechanism activation or lack thereof [17] (A12.9). The MNoE also prioritized using theory to guide articulation of putative mechanisms (A12.3) and the examination of mechanisms across diverse contexts to explore how mechanisms might be activated differently or over a different timeframe across contexts, populations, or interventions (A12.4). Moreover, the MNoE acknowledged the potential to hyperfocus on intrapersonal mechanisms of behavior change, which has a mounting evidence base [16, 72, 102]. To complement this individually focused work, the MNoE explicitly prioritized exploring mechanisms at aggregate levels of analysis that are less studied (e.g., community or policy levels), but where structures should be targeted to improve (A12.6) equitable outcomes [32, 50, 52, 58, 75, 87, 103, 104].

Theory, causality, and context

Because implementation science is a convergence of many disciplines, there are relevant classic theories (e.g., from social psychology, business, economics, education, anthropology) that articulate mechanisms [105]. Most utilized are frameworks, from which the theoretical underpinnings that depict relationships among constructs and enable prediction through propositions are absent, leaving a list of measurable factors organized by conceptual coherence, as in the case of the Theoretical Domains Framework [106] and the updated Consolidated Framework for Implementation Research [107]. Kislov et al. [108] wrote about the importance of theorizing as a process that could enable implementation scientists to bidirectionally inform and learn from empirical data to test and advance generalizable knowledge and theory working at the mid-range level to develop and refine grand theories. More recently, Meza and colleagues [109] attempted to make theorizing more accessible to researchers, and although they use theorizing about determinants as their use case, they name mechanisms as a critical component of causal chains that explain *how* an implementation initiative is successful. Toward this goal, the MNoE prioritized activities that would incorporate theory (G13) through examples and guidance (G14). Actions included differentiating causal theory from program theory (A13.1), modifying implementation science “grand” theories to better represent mechanisms (A13.2), and making the notion of timing more explicit in the theory of change (A13.6). Consistent with the above-mentioned calls to prioritize theory, the MNoE prioritized

guidance to choose relevant theories for study planning (A14.4), to fully integrate theory in an implementation study of mechanisms (A14.3), and to clarify how theory is used to articulate mechanisms (A14.2).

Beyond the five priority clusters initially identified in the concept mapping of challenges stymying the field, two new priority clusters of actions emerged through MNoE discussions: *Engagement* and *Growing the Field*. These priorities reflect critical areas of work to advance the study of implementation mechanisms. The Engagement cluster represents actions that, if prioritized early, would amplify the impact of actions in other clusters. Growing the Field actions are foundational and/or underpin the work of the other clusters, which might not be possible otherwise.

Engagement

In terms of Engagement, the MNoE thought it critical to engage the policy and practice community, as well as funders of implementation science. The MNoE emphasized that the policy and practice communities are critical to establishing mechanisms, yet this area of science can feel obscure and pedantic to those communities. Funders were identified as a separate target for engagement because many of the prioritized actions do not fit neatly within traditional funding mechanisms.

The MNoE articulated priorities for engaging policy and practice partners in mechanism identification, validation, and testing (G15) and in using methods to obtain practice-based data and confirm theory (G16). The MNoE recommended plain-language mechanism definitions and de-jargonized questions for identifying mechanisms with community partners to help scientific teams learn from their perspectives (A15.1). Plain language was repeatedly emphasized because the term “mechanisms” itself may limit idea generation or perceptions of applicability as it tends to surface mechanical or biological underpinnings (A15.2, 15.3). The MNoE saw the policy and practice communities, broadly construed, as central to unearthing putative mechanisms and generated actions for facilitating their engagement, including motivating them to study mechanisms (A15.5), supporting them to collect and track data on mechanisms (A15.7), providing feedback (A15.8), and constructing causal pathways (A15.9). For instance, group model building presents a directed approach to engaging participants in articulating implementation mechanisms [110]. There are several more general frameworks, models, and approaches that can guide this kind of policy and practice community engagement, including community-based participatory research [111], community partnered participatory research [112], participatory action research

[113], integrated knowledge translation [114], and user-centered design [67, 115].

The MNoE articulated goals for engaging funders including emphasizing the study of mechanisms as a priority (G17), growing mechanism expertise (G18), and considering new funding models to support mechanism-focused research (G19). The MNoE suggested that it might be important to clarify, or confirm, that mechanism-focused research can lead to more parsimonious and efficient implementation approaches and reproducibility (A17.5). To this end, the MNoE surfaced the possibility of using scientific administrative supplements for mechanism data testing (A17.1) and making the study of mechanisms an explicit priority in funding opportunities (A17.2). To ensure mechanism evaluation fits within grant budget limits, the MNoE suggested deprioritizing patient and clinical outcomes when the intervention's efficacy and/or effectiveness is robust and adaptation is minimal (A17.3).

The MNoE highlighted the importance of ensuring that grant reviewers are familiar with implementation mechanisms and can critically review grant proposals on these topics. To grow the capacity of reviewers (and the extramural community more broadly), the MNoE proposed specialized training for reviewers or the reviewer pipeline (A18.1), including conference workshops (A18.2) and mock study sections that center applications proposing implementation mechanisms research (A18.3). The MNoE envisioned a guideline document that would support assessing a study proposal's plan to evaluate implementation mechanisms and scaffold learning key elements for mechanisms testing for those writing grant applications (A18.4).

Finally, the MNoE articulated several ideas for funding opportunities or suggested elements to emphasize within planned/existing funding opportunities. These included funding a coordinating center to harmonize measures, create the infrastructure for data collection, and integrate findings across numerous studies examining implementation strategy mechanisms (A19.5). The MNoE also wondered about the possibility of mechanism evaluation occurring during a follow-up (e.g., renewal) grant funding period, leveraging the longitudinal nature of the evaluation and the need to engage multiple partners (A19.4). In addition to large cross-study or longer initiatives, the MNoE suggested small and nimble grant opportunities that allow for discrete strategy testing and the need to pivot if the strategy “signal” is not detected (A19.1).

Growing the field

Throughout the Deep Dive, the MNoE called for multi-pronged efforts to grow the field. The MNoE recommended resources for evaluating mechanisms that could

scaffold scientists' efforts (G20) as well as more robust training that would help scholars grow new skillsets in the study of implementation mechanisms (G21). The MNoE prioritized guidance and resources regarding topics such as: how to test a strategy causal pathway (A20.1), how to choose the most appropriate outcome for a given mechanism (A20.2), how to isolate a mechanism from other factors in a causal pathway (A20.3, 20.4), how to disentangle the intervention from implementation strategies (A20.5), when to adapt the intervention versus modify the implementation strategy (A20.6), and when to change the strategy for the context versus change the context using the strategy based on our understanding of mechanisms (A20.8). With respect to this last topic, many scholars see contextual targets that, if changed, boast greater societal benefit (e.g., consideration of social determinants of health; addressing structural racism) as being inappropriate targets for implementation scientists, unless the evidence-based intervention itself is directed at those higher levels. Yet, implementing within existing structures can exacerbate inequities. These are critical questions, answers to which would have serious practical implications if, indeed, empirical guidance could be curated. Moreover, these questions are faced by numerous research teams, making the investment in generating such guidance even more valuable. These are the types of empirical evidence and associated resources that might come from larger investments to support the study of mechanisms, such as center grant awards, from which the scientific field and practice community stand to benefit.

The MNoE also generated several actions that were characterized as training-like approaches to build capacity. These included efforts like brief, recorded, didactic sessions regarding definitional issues surrounding mechanisms (A21.1), as well as more process-oriented training on, for example, how to specify causal chains (A21.2) and how to regularly reflect on why an implementation strategy is or is not working throughout the course of a study (A21.3). A team at the IMPACT Center has begun to produce videos aligned with these actions with funding from the US National Institute of Mental Health (P50MH126219) [116]. Acknowledging that videos might not be sufficient, this team has also offered in-person workshop training followed by office hours and one year of expert consultation around causal pathway diagramming [117]. Multipronged training and consultation will be critical for capacity building in new areas like the study of implementation mechanisms. Somewhat innovative actions were also shared, including a workgroup to support a series of training grants focused on the study of mechanisms (A21.4) and a data summit in

which underutilized data from grants could be made available for secondary analysis paired with postdoctoral researchers using a shared mentoring model. The sentiment was that the expertise required to advance the study of mechanisms is sparse and approaches that extend the reach to new teams and data sources would be critical.

Although several of the above suggestions function as dissemination, the MNoE articulated four specific dissemination-related goals: produce focused manuscripts (G22); partner with journals to generate new paper types (G23); establish forums for dialog (G24); and generate broad interest using strategies that reach community partners (G25). The MNoE articulated numerous manuscripts that would be helpful such as *Mechanisms Made Too Simple*, inspired by Curran's article [118]. They also imagined new paper types, such as one that centered on "learning from failure with wisdom," which would essentially unpack implementation failures with a mechanistic lens. An example of such a commentary was written by researchers (not members of the original research team) regarding a recently published null trial that appears fruitful [17], and yet another approach is to ensure that implementers have opportunities to share "salvage strategies" that make the most out of opportunities to retain rigor when unexpected events threaten to derail studies that could shed light on mechanisms [100, 101]. Finally, the MNoE underscored the importance of clarifying the "why" behind the study of mechanisms, particularly given the importance of learning from and supporting the policy and practice community. As they discussed dissemination, they surfaced a marketing problem in that not all would agree that the study of mechanisms could advance both science and practice, and some members believed this reductionist approach is misaligned with the very nature of implementation [20].

Limitations

Importantly, the MNoE may not be representative of those who could contribute and/or stand to benefit from this work. Although we made efforts to engage researchers from outside the United States (US; e.g., open attendance during a SIRC breakout; international representation in MNoE paper writing groups), the inputs and outputs of this research agenda largely reflect a US perspective. Indeed, parallel and complementary work from scholars in the United Kingdom (UK) includes an ontology of mechanisms of action in behavior change interventions that begins to address several aspects of the Research Agenda [119]. We hope readers with different perspectives will consider building from the US and UK work, for example, writing a commentary to further the

dialogue and/or pursuing research that advances some of the priorities discussed above. Moreover, although some of the MNoE identify more as clinically or practically oriented researchers, the MNoE did not include policy and practice community members. Thus, it is likely that new actions across the priority clusters would have emerged if different groups were engaged in the process of generating this content. Also, the focus of this research agenda is on implementation strategy mechanisms, or the processes through which strategies exert their effects to achieve outcomes [30]. This focus overlooks contextual mechanisms, such as those surfaced through realist reviews [120]. This focus is consistent with prior work by our team [19], but can limit the field's ability to explain how and why implementation occurs.

Conclusion

Implementation science needs to further expand from *what* works to *how* and *why* certain strategies work, for whom, when, and in which contexts [121]. This research agenda outlines a roadmap of concrete actions for advancing the study of mechanisms. To carry out this research agenda, concerted and strategic effort is needed. There are numerous training forums that grow implementation research capacity [122]. We hope some will highlight the priorities articulated herein, bring together transdisciplinary experts with mechanism-specific expertise, and contribute to the study of implementation mechanisms.

Abbreviations

SIRC Society for Implementation Research Collaboration
MNoE Mechanisms Network of Expertise

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

CCL, HEF, BK, AS, GC, and BJP contributed to the conceptualization of the manuscript, engaged in the coding, and participated in data interpretation. CCL drafted the introduction, results, and discussion. HEF and GC drafted the method section. ARL and BA reviewed preliminary results and contributed to revisions to the results table. BJP and CCL worked the manuscript through several cycles of review by all coauthors. All authors (CCL, HEF, BK, AS, GC, BJP, GAA, RSB, BSM, BJW, NJW, MF, SM, MP, LS, AW, CWB, SWS) reviewed, edited, and approved the final content of the manuscript.

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Availability of data and materials

N/A.

Declarations

Ethics approval and consent to participate

This study was reviewed and approved by Kaiser Permanente Washington Health Research Institute's IRB and was deemed Not Human Subjects Research.

Consent for publication

N/A.

Competing interests

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