## DEBATE



# When the parts are greater than the whole: how understanding mechanisms can advance implementation research

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## Abstract

**Background** Does the importance of context in implementation imply that generalizing about the effects of strategies is ultimately limited? Conceptual approaches for generalizing in the presence of significant contextual heterogeneity could advance implementation research but require novel perspectives.

**Main body** Drawing from perspectives from Realist approaches, Pearl's transportability framework and philosophy of science, this paper outlines a mechanism-based approach to generalizing about the effects of implementation strategies. We suggest that understanding mechanisms creates a conceptual bridge between the effects of a strategy and the influence of the implementation context. Using directed acyclic graphs to represent the mechanisms of strategies, we show how conceptualizing mediators of overall effects offer a basis for considering the effects of context. Hence, theorizing and testing a mechanistic understanding enriches the ways in which we can consider how context could change those effects. Such an approach allows us to understand how a strategy works within a given implementation context, determine what information from new contexts are needed to infer across contexts, and if that information is available, what those effects would be — thereby advancing generalizing in implementation research. We consider particular implementation strategies (e.g., Community Adherence Groups and practice facilitation) as examples to illustrate generalizing into different contexts.

**Conclusion** Mechanisms can help implementation research by simultaneously accommodating the importance of context as well as the imperative to generalize. A shift towards a mechanism-focused approach that goes beyond identifying barriers and facilitators can enhance the value of implementation research.

Keywords Context, Generalizability, Mechanisms, Implementation strategies

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## **Contributions to the literature**

- Explicating the mechanisms of implementation strategies — the sum of the pathways that mediate their effects — offers a conceptual basis for considering how contexts can influence those effects
- Given the need for inferring across implementing contexts, a mechanistic explication of implementation strategies is an important research priority for implementation research
- Mechanisms can help move the field from the wellestablished observation that context matters toward understanding of context that matters and how, when and where it matters

## Implementation science: generalizing and its discontents

While the science of implementation has made tremendous strides, some fundamental questions remain incompletely settled. One such question is whether the diversity of implementation contexts (e.g., varying organizational, financial and social factors) constrain or even preclude generalizing about the effects of implementation strategies (in which we study a particular group and apply findings to a larger target group). Context is widely seen as an important driver of implementation success [1-5]. As a consequence, therefore, differences across implementing contexts [6] imply that implementation strategies will have different effects in many of these different contexts. Empiric studies confirm suspected heterogeneity. For example, systematic reviews of audit and feedback [7] a widely used strategy — find effects that range from -30% to +300% [8, 9]. While some drivers of differences are known (e.g., the intensity of the intervention, the level of performance at baseline), context likely also plays an important role [9].

If every implementation context — defined by a particular combination of organizational, social, and human features — is truly distinctive (and not entirely measurable), how can we generalize from a particular research study about an implementation strategy to the wider world? Natural sciences, for example, claim laws that are invariant almost everywhere (e.g., laws of gravity). Interventions identified in biological sciences (e.g., medications) also have clinical effects that apply broadly: medications for treating HIV, tuberculosis, hypertension, and other disorders essentially work if used in virtually all people with those conditions, irrespective of physiological, social, economic, or other contexts [10]. Some perspectives from social and behavioral sciences which are closer to implementation research — doubt that we can generalize from particulars to the wider world because contexts are too heterogenous. Instead, they emphasize conceptual abstraction or case-to-case transfer as alternatives [11]. Can we generalize from particulars to diverse external contexts in implementation research, and if so, how?

In this paper, we suggest that understanding mechanisms of implementation strategies provides a helpful approach to generalizing from a study to wider world in implementation science. We draw from recent papers about mechanisms in implementation science and also from philosophy of science [12], causal inference, policy analysis [13], and Realist evaluation [14]. We argue that generalizing about effects of a strategy tested in a particular context into diverse external contexts is possible even when effects differ in those target contexts. We show how to do so through combining an understanding of the mechanisms of a strategy (derived in part from studies with information from implementation contexts outside of those studies (into which we want to infer). This approach has implications for study design, measurements and the types of questions prioritized in the field of implementation research.

### Generalizing 1.0: external validity

Traditionally, one of the prevailing paradigms about generalizing research findings conceives of the process as taking a result observed in a study (or set of studies), and applying that result to an external "real-world" context outside of those studies [15]. This type of generalizing assumes that there is one meaningful answer in that "real-world." Under such an assumption, finding the "real-world" answer in research depends on conducting studies in the organizational, social, economic and demographic contexts that are representative of the "real-world" (Fig. 1a). External validity can therefore be achieved through avoiding research related artifacts and rigorous research designs to manage bias. If successful, a study will therefore reasonably approximate effects in the "real-world." The critical assumption is that there is one meaningful real-world effect provides a premise for generalizing (Fig. 1a). Pragmatic trial designs, for example, seek to ensure applicability in the real world through studying patients in care settings that are typical of realworld, interventions that are usable by typical health care delivery units, minimizing study related follow-up and other techniques [16].

Generalizing through applying a finding from a study to external real-world populations and contexts may be reasonable for biological effects of clinical interventions (e.g., medications), but may be less of a fit for implementation research. For example, clinical trials among persons living with HIV show that antiretroviral therapy with medications such as integrase inhibitors lead to



**Fig. 1** Traditional vs. Modern Generalization. A traditional approach to generalizing take effects observed in a study and seeks to apply those effects in a larger population external to the study (Panel **A**). If the underlying units of interest (whether patient, providers or health care units) is well characterized, the sampling probabilities into the study are known, typical threats to validity are adequately managed (e.g., measurement error), and the study itself does not create an artifactual environment, findings can be used to infer (with statistical uncertainty) about effects in the external population and contexts. Implementation research often assumes, in contrast, there is a meaningful diversity of contexts in the real world. This implies that the effects of any implementation strategy will differ across those contexts. Instead of identifying a single effect that applies in all contexts, the field may need to seek effects in one context in a way that enables inferring in other external contexts (Panel **B**), even when the effects will differ. We seek an approach to generalizing such that a study (Panel B) in one of the three contexts (Context A) can be used to infer about effects in other contexts such as Context B (where the strategy improves outcomes by threefold) or Context C (where the strategy has no effect). Is that possible?

biological suppression of the virus in virtually all study participants [17]. This biological effect applies virtually everywhere irrespective of social, organizational or other element of context. Likewise, the research finding that adjunctive corticosteroids in HIV-related *Pneumocystis jorvecii* pneumonia improves survival by 30%–50% [18] applies to most all patients with the PJP pneumonia. Even though there are many exceptions [19, 20] and debate about design of research to optimize this kind of generalizing continues [20], application of a clinical effects found in a study to the wider world of patients can often be valid when we are seeking to generalize biological effects [20, 21]. This simple extrapolation, however, may not work in implementation research.

## **Generalizing 2.0: external validities**

In implementation research, on the other hand, applying the effects of an implementation strategy found in a study (conducted in one particular context) to the external real-world is often neiher possible nor desirable. If we believe that effects of strategies (e.g., audit and feedback, practice facilitation) differ meaningfully across contexts, then research finding — even if conducted without study artifact — will be unable to directly represent effects in a meaningful range of implementing contexts. In addition, the field of implementation science is committed to finding optimal solutions in many distinctive contexts. The implied heterogeneity of the effects of implementation strategies is therefore an important feature of the field (and motivates thinking about tailoring and adaptation). Saying that any finding in a is "externally valid" is not meaningful if we accept the premise that there are many distinctive real-world contexts that influence the effects of strategies. Different effects in different contexts are not nuisances to be managed, but a feature of the reality we seek to study (Fig. 1B).

Giving up on seeking a single study effect that applies across all external contexts calls for implementation research to explore alternative approaches to generalizing from particulars to the wider world. One alternative might be to find a way to use effects found in one context to inform us about the effects in another, even if that effect differs. Instead of asking, therefore, whether a finding observed in a study conducted in Kaiser Permanente Northern California is "externally valid" or not, we would ask how we can use these finding in California to infer



**Fig. 2** Representing mechanisms of implementation strategies. We use a diagram (using conventions of a directed acyclic graph) to illustrate the components of a mechanism. In this representation, a Strategy (S) is the implementation actions undertaken to change an implementing outcome. Mediators (M) are all the nodes or steps in a directed pathway from the Strategy to the Outcome (O) passes. Pathways (P) are all unique directed paths from the Strategy to the Outcome. For illustrative purposes, the Strategy (e.g., training) in this diagram acts through three mediators and through three different pathways. Pathway 1 is S-M1-O. Pathway 2 is S-M1-M2-M3-O. Pathway 3 is S-M2-M3-O. Note that M1 is not only a mediator of S through the S-M1-O pathway, but also a moderator of the effect of S-M2-M3-O (by also acting on M2). We consider the "mechanism" as all the mediators and pathways between S and O

about effects in Michigan or Missouri — and many other places that differ in organizational, social and economic features. In short, implementation science can make generalizing tractable through modest but important adaptations to the goal of generalization.

### Mechanisms and external validities

Understanding how a strategy works — its mechanism [22] — opens the door to a kind of generalizing potentially more useful for implementation science. Drawing from approaches to understand science through explanations, we consider a mechanism to be an assembly of concepts and causal relationships that underlie an overall effect or phenomenon. One definition states that a mechanism has four basic elements: [1] an overall phenomenon or effect, (2) the parts that underlie the effect, (3) causal relationships between the parts, and (4) stable organization of the parts [23]. In this arena, "mechanisms are understood as causal systems, exhibiting a characteristic organization, with multiple causal factors that work together in a coordinated manner to produce some effect of interest." [24].

Applied to implementation research, we see a mechanism of an implementation strategy as all the pathways through which a strategy's effects take place. By conceptualizing the parts or components of an implementation strategy's effects (i.e., it's mechanism), we enable principled consideration of how a given external context could influence the effects of the implementation strategy. Each of the parts that underlie an effect (made of mediators) presents an opportunity to investigate how context might interact with that step. Mechanisms enable us to move from the truism *that context matters*, toward understanding *context that matters* by provoking theorization of (and eventually testing of) specific causal relationships. This kind of approach will allow the field to shift from seeking external validity to meaningful external *validities*.

## Using causal diagrams to explicate mechanisms

In this paper, we use directed acyclic graphs (DAG's) to represent the mechanisms of implementation strategies [25]. In these graphs — widely used in epidemiology and causal inference — arrows represent effects and nodes represent concepts (or variables in statistical parlance) (Fig. 2). Each node in a directed sequence from the strategy to the outcome is a mediator of the effects of the strategy. We refer to any directed sequence from the strategy to the outcomes as a pathway. Two arrows pointing into one node is one way to implies that the effect of one is affected by the other (a phenomenon when projected onto a numerical scale represents effect modification) [26]. When two pathways in a mechanism intersect, a mediator also acts as a moderator. We draw from the idea of "selection nodes" to represent contextual factors that differ between a source context where a study occurred and an external context [27]. These contextual factors are not on the pathway from the strategy to the effects of the strategy and therefore act only as moderators.

DAG's offer a uniquely flexible tool — but not the only one [28, 29] — for developing and testing theories about the mechanisms of implementation strategies [30]. Representing a strategy's mechanism [22] as a DAG makes explicit how the steps in the mechanism represents a potential receptacle for contextual effects. If a strategy (S) has an effect on an outcome (O) (Fig. 3), the absence of a mediator (Z) between the strategy (S) and the outcome (O) precludes representation of how contextual factors



**Fig. 3** Mediators enables consideration of context. Absence of a hypothesized mechanism limits analysis of context (Panel **A**). Proposed mechanisms — in this case a single mediator for simplicity — offers a conceptual receptacle for how context might influence a strategy's effects (Panel **B**). In the convention of directed acyclic diagrams, two arrows that point into one node implies that the effect of each arrow is influenced by the other, in this case representing how context effects the effect of the strategy on the outcome

(C) that could influence the effect of X on Z (other than through effects on O itself). When we conceptualize and represent [3] a mediator between (S) and (O), we create a receptible for the particular context's effects on that mediator, and therefore, on the outcome as well. Causal Loop Diagrams [31] and Causal Pathways Diagrams are other graphical tools to aid thinking about contextual effects [32, 33].

Research to understand mechanisms builds on insights from Realist evaluation [34]. In the Realist perspective, effects of programs and policies are often considered instances of a theory [35]. Given the highly contextualized effects of complex programs, Realist approaches do not seek statement about whether such a program "works." Instead, Realist evaluation describe how programs work in context [36]. Operationally, Realist evaluation uses program theory to identify specific interactions between how a program works (i.e., its mechanism) and context [37] to generate "context-mechanism-outcome" statements. Realist approaches, however, offer less emphasis on methods for using effects found in one context to infer in other, wider, external contexts [34-37]. Use of findings from one study context and infer in other *external* contexts (even when that effect differs) has been, on the other hand, a focus of the transportability approach pioneered by Pearl and colleagues [27, 38]. This approach "...provide[s] a formal definition of the notion of 'transportability,' or 'external validity,' as a license to transfer causal information from experimental studies to a different population." [39] In other words, the approach uses graphical and mathematical approaches to provide a way of using knowledge found in one population to estimate effects in another [27]. The transportability approach implies that that *theorizing* about how an implementation strategy exerts it effects — the mediating pathways of the effect — are an important step in developing potentially generalizing claims. The transportability approach has not been used to date to motivate the theorization process in implementation science.

## Example community adherence groups: generalizing across contexts

We use a tangible example to illustrate how mechanisms can help with generalizing. Since 2005, rapid scale up of HIV treatment has occurred in many places of the world that previously had limited infrastructure for longitudinal outpatient care [40]. In the early phase of the global public health effort, public health agencies and governments rapidly built clinics, trained large numbers of health care workers and assembled supply chains [41]. To facilitate scale up, programs emphasized standardization. As a result, virtually all patients were given 30 days between appointments. Over time, however, it became clear that monthly visits were an untenable burden for patients over the long run [42, 43]. Newer models of care emerged, including the Community Adherence Group [44]. In this schema, six neighbors on HIV treatment would form a group and send one member each month



**Fig. 4** Mechanism and Context for CAG's. A directed acyclic graph representing how a Community Adherence Group — a strategy composed of a forming a group of patients to distribute medications to each other — has effects (Panel **A**). Once offered, all effects of a CAG are mediated by acceptability and participation in the group, with subsequent steps that operate through four mediators drawn from the literature: (1) opportunity costs, (2) activation, (3) social support and (4) decongestion of clinics. Each mediator represented in this graph invites consideration of how specific contextual elements (that differ between two contexts) could influence the strategy. Each (Panel **B**) contextual effect is shown in red and includes for illustrative purposes (1) geography and rurality, (2) level of stigma and (3) human resources for health

to pick up medications for the other five members. That individual who travels on behalf of the others would also receive a bi-annual required blood tests at that visit. CAGs could be considered a type of "involve patients in implementation effort" in the Expert Recommendation for Implementing Change strategy compilation [45].

CAGs were first shown to have effects in rural Mozambique, but would they have similar effects elsewhere? We do so by using a mechanistic explication of how CAG's work — a descriptive theory of the strategy — based on literature to illustrate (Fig. 4) [46–48]). Published research suggests that CAG's increase retention by reducing opportunity costs of clinical encounters (Step 1). CAG membership also was found in research to increase patient activation and accountability (Step 2 [49]) as well as enable greater peer and social support (Step 3 [48]). Finally, by decongesting clinics, CAG's reduced size of ques and alleviated provider burden (Step 4 [47]). Some of these pathways intersect. For example, decongestion of the clinics reduces waiting times, therefore also contributing to further reduction in opportunity costs.

If CAGs have effects in rural Mozambique where they were originally studied, what effects might they have in urban Tanzania? The proposed multi-pathway mechanism of the effect of CAG's points out contextual elements that are relevant for considering effects in the new setting (Fig. 4B).

• First, the acceptability of the CAG once offered will have important effects on the ability of the model to act through all other mechanisms (i.e., if patients refuse to join, none of the benefits will accrue). The importance of acceptability implies that differences in the level of HIV stigma across communities will play a central role in effects. Higher stigma makes disclosure of HIV status—necessary for joining a CAG— more difficult.

- Second, the rurality of the context influences the effects of CAGs that work through reducing opportunity costs. The greater the distances, the greater the benefit of membership in a CAG. Differences in distances between contexts will influence the effects of CAG's by acting on the "opportunity cost" mediator.
- CAG's also work through enhancing patient activation. Research suggests that differences in the level of treatment literacy, educational attainment, and selfefficacy across contexts also influence the effects of a CAG through acting on the "patient activation" node.
- Staff-to-patient ratios (which differ between rural and urban clinics) influences the effect of the CAG that operate through two pathways: reduction of opportunity costs as well as the improving the quality of the encounter. This effect, however, is likely influenced by differences in staffing and other human resources for health between two contexts . The severity of understaffing will therefore influence effects that pass through reducing patient volumes at clinic.

Each of these considerations about how contextual factors (e.g., stigma) can affect the success of offering a CAG is enabled by conceptualization of a mediator. An explanatory depiction of the effects of a strategy and the constituent parts of the effects (i.e., it's mechanism) provides a transparent way to explore elements of context. The diagram acts as a working theory of how a CAG works and how that effect would likely vary across contexts. While in this paper we emphasize qualitative aspects, transportability also provides a mathematically grounded approach to estimate effects across different contexts.





**Fig. 5** Mechanism and Context for Facilitation. Simplified mechanistic representation of healthcare facilitation for illustrative purposes. In this simplified diagram, this strategy is portrayed as a facilitator engaging with a new organizational network to provide resources and skill for change. The strategy unfolds through three key mediators: (1) acceptance into the care system, which involves gaining the healthcare system's approval and support for new practices; (2) buy-in from leadership, needed for securing broader organizational support; and (3) cultivation of internal champions who advocate for and sustain the new initiatives (Panel **A**). These elements work together to build (5) trust and coherence around the proposed activities. The diagram's mediators invite consideration of organizational readiness for change as a contextual factor that could play a crucial role in the process by acting on acceptance (Panel **B**). The unit's ability to experiment with new activities depends on creating slack in the system—essentially, allowing resources and time for experimentation with new processes and approaches. This slack is necessary for testing and refining new ways of thinking, ensuring that the healthcare system can adapt and integrate innovative practices

## Example of practice facilitation: generalizing across contexts

Practice or healthcare facilitation [50] is often used to introduce or enhance the use of evidence-based interventions [51]. While numerous studies have demonstrated the utility or effectiveness of practice facilitation, research to understand how facilitation works [52] — mechanistically — remains an area of inquiry. A recent paper sought to use a structured process, including a Delphi process, to assemble a mechanistic representation of facilitation [51]. We use a simplified version of the mechanism from this recent paper to illustrate how a mechanistic conceptualization of healthcare facilitation enables generalizing when static effects are not probable (Fig. 5).

- This mechanism begins with an attempt by a facilitator to offer a package of socio-technical resources to a health care unit. This offer acts through acceptability of the facilitator into the health care workforce, buy in from leadership and champions (Mediators 1, 2 and 3).
- Literature points to the importance of managerial and leadership to enable facility buy-in . If this is true, then strategies for facilitation should emphasize lead-

ership engagement not only as a means to building skills, but also in order to legitimize the facilitator within the social system of the facility.

- Leadership then acts as both a mediator of the effect as well as moderator of the effect of facilitation . Likewise, cultivating internal champions acts through building skills in their peers (as mavens of new practices) as well as on social legitimization of the facilitator.
- The diagram implies that much of the effect of facilitation are dependent on membership in the social system. This theorized mechanism also privileges (rightly or wrongly) the social aspects of facilitation and gives it a prominent place in the mechanism, as three of the five pathways operate through this mediator.
- Each of these steps then contributes to building coherence, skills, and collective action (Mediator 5), which will in turn influence practice change. We draw from Normalization Process Theory to conceptualize how facilitation changes practice through a sequence of iterative processes that transform a new practice into something that is "normal" and recedes from view [53].

The hypothesized mechanism creates an opportunity to consider how contextual factors would influence the effect (of facilitation on practice change) because it identifies the critical steps in the chain of events that constitute the effect.

- Readiness for change [54], for example, is an organizational feature that is likely widely varying and which will influence the success of the facilitator's direct efforts as well as those mediated through leadership and champions. In other words, the right organizational environment will magnify all the pathways that pass-through acceptance.
- Likewise organizational slack [55]— surplus capacity thought to be needed for innovation is likely to influence the effects of all efforts since all pathways pass through "coherence, participation and skills node." In this mechanism, organizational slack therefore stands out as a distal and potentially influential contextual factor that alternations in the strength of the previous pathways will not be able to "get around."

As in the previous example, the explanatory theory of how facilitation works, represented as a directed acyclic graph invites thinking about what and how contextual factors might be relevant.

## Implications of a mechanism-based approach for generalizing implementation strategies

A mechanisms-based approach to generalizing from a study to the wider world has important implications for the design, conduct and implications of implementation research. Some of the potential implications are subtle, but could influence the way implementation research is conducted.

## Mechanisms can help implementation science progress as a field by enabling generalization without side-stepping context

For implementation science to mature as a field, we need to better understand the "treatment effects" of implementation strategies. Using a traditional approach to generalizing, contextual heterogeneity appears to pose a constraint to generalizing about the effects of strategies — and therefore a challenge to the maturation of the field more generally. A more nuanced approach to generalizing, based on mechanisms, can help overcome this impasse and advance the goals of the field. The field of implementation science initially sought to find strategies that would work broadly, but was confronted by the realization that diverse contexts meant invariant effects were not possible. The field then turned to research on tailoring strategies so that implementation strategies could better fit a given context - with a focus on how to find what works in a particular context. Turning our attention to the mechanisms of strategies allows knowledge of how strategies interact with contexts and therefore the conditions that enable (and conversely disable) effects. In short, mechanisms can help implementation research to expand the kinds of generalizations available to the field and develop inferences about strategies for many contexts.

## Mechanistic thinking about implementation strategies allows separating context that matters from context that does not

Mechanisms also help the field overcome the "context trap" — the sterile truism that "context matters." The conclusion that context matters, if it goes no further, does not help advance our understanding of how to improve implementation. implementation research has sought to categorize different types of contexts . A different approach to understanding context begins with a strategy and then using the mechanism of that strategy, asks how any of the mediators of that mechanism are influenced by context. Proceeding from mechanism to context means that we create a principled way in which research can understand, distill and measure specific elements of context. Mechanism allows us to move from the belief that "context matters" to the study of "context that matters".

Returning to the example of the CAGs, if the hypothesized mechanism of reducing opportunity costs implies that differences in the distance across two geographies is a crucial element of context. Distance between facility and residence, however, is not necessarily relevant context for all implementation strategies. For example, studies have identified poor provider-patient communication as a reason for disengagement in public health HIV treatment services [56]. As a result, some research has sought to test communication-based implementation strategies to improve use of evidence-based HIV treatment [57]. Implementation strategies based on improving communications such as these may depend on contextual factors such as worker morale or community empowerment, but context such as distance from clinic to residence - so central for generalizing about CAG's - may not be relevant. Mechanisms therefore act as a filter for elements of context that have effects on a particular strategy.

## Understanding the boundary of generalities allows implementation science to generalize better, not just more

A mechanism-based approach also allows us to be clear about whether can anticipate effects of a strategy in a given context and when we cannot (i.e., because we lack the information needed to make a claim). Intuitively, we know that we often need some information or assumptions about a new context to infer about a strategy's effects in that context. Mechanisms give us one way to translate that intuition into a method. Some clinical treatments offer illustrative examples where information about a patient or group of patients is needed to anticipate effects of a treatment with a known mechanism. Medications used to treat breast cancer through blocking the estrogen receptor (e.g., tamoxifen) have clearest efficacy when used in people with breast cancer tumors that expresses the estrogen receptor [58]. Information from the patient (i.e., whether they have a tumor with the right receptor) is needed to decide whether the treatment will work or will not work. If we do not know whether the patient's tumor expresses the receptor, we cannot say whether effects would be positive or negative. Knowledge of tumor receptor expression separates what we can claim from what we cannot. While this is a clinical and not an implementation example, by analogy, if audit-andfeedback works through highlighting a performance gap [59], then we need to know about the credibility of data systems in a given context to anticipate effects in that particular context.

## Trials of implementation strategies should uncover mechanisms of effects to be pragmatic

Many champion pragmatic designs as one way to create generalizable knowledge that can be applied to "real world" settings. This approach suggests that representative study populations, use of administrative data, flexible follow up and interventions that can be implemented by typical health units will give us externally valid findings [60]. This approach relies on the assumption, however, that one effect exists which could be applicable "externally." If, however, true effects differ across context, then pragmatic trials that remove artifacts introduced by a trial environment might be necessary but not sufficient to optimize generalizing. A mechanistic approach suggests that measuring critical mediators of the strategy are useful for generalizing. This layer of measurement may be at odds with the parsimony advocated by pragmatic designs, but offers implementation researchers an alternative, and perhaps complementary, route to generalizing. Elucidating mechanisms can allow findings to be more *exportable* (using the metaphor of transportability).

One example comes from a cluster-randomized trial in Uganda. The investigators used a multi-component training-based strategy targeting the health care workers and increased HIV treatment initiation rates [61]. Qualitative data found that the approach worked ass anticipated through changing provider knowledge and attitudes. But the strategy also had unanticipated mechanisms of effect as well: even though the interventions were directed at formal health care workers, their knowledge trickled down to lay health care workers, who then introduced the ideas into the community, which meant new patients came to clinic expecting rapid treatment initiation. This pathway in the mechanism of the rapid treatment strategy - patient demand generation - implies that the effect of training health care workers could be augmented by inclusion of lay health care workers, who can then translate new practices into the community.

## Mechanistic thinking about implementation strategies suggests that generalizing is not the property of any one study, but rather the product of knowledge across an epistemic community

A modern view of generalizing based on mechanisms also helps relieves individual investigators and their studies of an unfair burden of being solely responsible for "generalizability." While it is true that in implementation science, we seek to design studies to be widely applicable, we also cannot expect single studies to make scientific claims about use or usability in a range of environments. Research to advance a generalizable understanding of the effects of community-adherence groups would combine data about mechanisms in one context (e.g., reducing opportunity costs) with factors that affect opportunity costs in a variety of contexts (e.g., distance between residence and clinic). A trial of an implementation strategy (e.g., CAG's) will offer only part of the picture, with the rest comprised of knowledge from an external target context. As another example, consider a study that finds that the ratio of providers to patients is the primary moderator of practice change. Measurement facility staffing could indicate whether the change could be taken up across the country. The information needed to generalize is not something that a study about a strategy can itself do, but that the wider research community is likely able to achieve.

### Limitations

This paper does not stem from, not speak to, all ontological traditions, particularly constructivist approaches and notions of transferability [62]. Of note, however, Realism — which we draw concepts from — is based on critiques of both positivism as well as constructivism [63]. Any argument about generalizing is likely to be highly contested even within an ontological perspective and is unlikely to satisfy all ontological positions and methodological approaches. Some have argued that epidemiological and statistical approaches to generalizing are inherently "colonial" - a view that some in implementation science seem congenial to [64]. That proposition would, however, implicitly epistemically malign a rising cadre of quantitative scientists, including statisticians, epidemiologists, and others in from formerly colonized societies Africa, Asia and Latin America who wield increasing global influence [65]. Nevertheless, unfair epistemic advantage are important areas for implementation science to grapple with [66]. Core functions have been proposed in implementation science as "things that work across contexts" and offer some insights into the issue of generalizing [67]. Considering them incontrovertible, however, would make the mistake of prematurely foreclosing on unresolved conversations that will ultimately strengthen the field. Finally, does explicating the basis of generalizing pose unreasonable demands on practitioners in day-to-day work? We believe that scientific explication can occur in tandem with practice in implementation science, just as it does in all social sciences.

## Conclusions

Understanding mechanisms of implementation strategies reveals contextual dependencies of the effects of those strategies. Theorizing about potential mechanisms can enable progress in research because they can conceptualize both key mediators as well as contextual factors that could affect those mediators. As these insights come into greater focus, the field may be able to better estimate the kinds of effects a set of practice and behavior change activities (whether training, audit and feedback, facilitation or myriad others) would have in a given set of contextual conditions. Generalizing in implementation science requires a more nuanced re-imagination of the scientific act of inferring broadly. While methodological challenges in the quantitative application of methods such as transportability and mediation [68] analysis exist, implementation science can also make use of qualitative insights [69] that combine mechanistic and contextual information to generalize. A mechanismbased approach advances our use barriers and facilitators by weaving concepts into an explanatory system. A mechanism-based approach also provides an antidote to "logic model" approaches that bin important concepts and thereby undermines important theorizing about the specific relationships. Taking on mechanisms in implementation science and their role in generalizing also allows engagement with other fields in social sciences to advance the field.

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#### Authors' contributions

EG led the conceptualization, analysis, interpretation, and wrote the first draft and made additional substantive revisions to the manuscript. BP contributed to the design of the analysis and interpretation of findings and substantively revised the manuscript. CG contributed to the analysis, interpretation and substantively revised the manuscript. CL contributed to the analysis, interpretation and substantively revised the manuscript. AS contributed to the analysis, interpretation and substantively revised the manuscript. BK contributed to the analysis, conceptualization, interpretation and substantively revised the manuscript. All authors read and approved the final manuscript.

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#### Data availability

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

#### Declarations

#### Ethics approval and consent to participate

No human subjects involved.

### **Consent for publication**

No individual data.

#### **Competing interests**

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