

Opening the Black Box: A Causal Pathway Methodology for Precise Implementation Strategy Design

Sophie Pouzols

sophie.pouzols@chuv.ch

University of Lausanne Faculty of Biology and Medicine: Universite de Lausanne Faculte de biologie et medecine <https://orcid.org/0000-0002-2750-3519>

Jean-Louis Raisaro

Lausanne University Hospital: Centre Hospitalier Universitaire Vaudois

Cédric Mabire

University of Lausanne Faculty of Biology and Medicine: Universite de Lausanne Faculte de biologie et medecine

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Abstract

Background

Despite the growing use of implementation frameworks, there is still limited understanding of how implementation strategies influence contextual determinants in order to produce desired outcomes. Closing this knowledge gap is essential for developing effective, theory-informed, and tailored implementation strategies.

Methods

This study presents a seven-step approach that links implementation determinants with adapted strategies using the Consolidated Framework for Implementation Research, the Implementation Outcomes Framework, the Behavior Change Techniques Taxonomy, and the Expert Recommendations for Implementing Change (ERIC). Causal pathway diagrams guided the process of articulating the hypothesized causal mechanisms. This methodology was applied during the pre-implementation phase of a study that aimed to integrate a computerized decision support system for preventing hospital-acquired pressure injuries in a Swiss university hospital.

Results

The process identified context-specific barriers and facilitators, prioritized determinants, and mapped them to implementation antecedents and mechanisms of action. Adapted and prioritized implementation strategies were co-designed with stakeholders. The result was a strategy bundle tailored to local context, validated through iterative stakeholder engagement.

Conclusions

This methodology provides a transparent, rigorous, and participatory approach to strategy development that can enhance implementation precision and contribute to theory building in implementation science. The integration of numerous frameworks and the incorporation of stakeholder input provides a replicable model for the design of context-sensitive implementation strategies.

Contributions to the literature

- The methodology presented herein is characterized by its systematic approach, which integrates the CFIR, ERIC, BCTs, and IOF to formulate context-specific implementation strategies.
- This paper demonstrates the efficacy of causal pathway diagrams in mapping determinants to mechanisms of action and outcomes, thereby enhancing transparency and theoretical grounding.

- It provides a replicable and participatory process that supports co-design and stakeholder engagement in implementation planning.

Background

A critical step in successful implementation is a rigorous contextual analysis to identify implementation determinants - the factors that can either hinder or support the integration of new practices (1, 2). Understanding these determinants allows researchers and practitioners to select, adapt, and tailor strategies to the specific needs of a given setting (3–5). Albright et al. emphasize the importance of the exploration and preparation phases of implementation, where contextual understanding is essential (2).

Despite the progression from identifying determinants to selecting strategies, research detailing the development of these strategies and the explicit links between strategies and determinants, or implementation outcomes remains relatively limited (2, 6). While numerous implementation strategies have been identified, a deeper understanding of how these strategies are developed and their causal pathways to outcomes is needed (6–9).

Among the determinant frameworks, the Consolidated Framework for Implementation Research (CFIR) has become a widely used tool for characterizing contextual influences on implementation (2, 10, 11). The CFIR has been updated based on user feedback to improve its applicability (3). To address the CFIR determinants, the Expert Recommendations for Implementing Change (ERIC) compilation provides a structured list of implementation strategies (8). ERIC has also been the subject of refinement and adaptation efforts (4, 8, 12–16). In addition, implementation success is typically assessed using the Implementation Outcomes Framework (IOF), which defines key outcomes such as acceptability, adoption, feasibility, fidelity, dissemination, and sustainability (17, 18). Damschroder et al. (2022) further elaborate on the conceptualization of outcomes for implementation research (19). In the CFIR Outcomes Addendum, Damschroder et al. included acceptability, appropriateness, feasibility, implementation climate and implementation readiness as “Antecedent Assessments”, measures to “predict” implementation outcomes (19).

Despite the availability of these frameworks, there is limited understanding of the mechanisms through which implementation strategies influence determinants and lead to successful implementation (20). Investigating the mechanisms of action (MoAs) underlying the effectiveness of implementation strategies is an area that requires further attention. Understanding these mechanisms can improve the selection and adaptation of strategies.

Beyond identifying and tailoring strategies, the field has increasingly emphasized understanding how and why implementation strategies produce change. In 2018, Lewis et al. explicitly called for the field to transition from classification to causality by articulating the mechanisms through which strategies operate and linking them to outcomes (20). This call was recently reaffirmed and reframed as a major research opportunity by Luke et al. (2024), who emphasized exploring the “bridges and mechanisms” connecting strategies to systems-level change, and by Geng et al. (2023), who emphasized developing

adaptable, mechanism-focused approaches applicable across diverse contexts (21, 22). The methodology presented in this paper directly addresses these calls by offering a structured process for specifying and linking determinants, mechanisms of action, and outcomes within a practical implementation setting.

By applying a structured approach integrating CFIR, ERIC, BCT and IOF with Causal Pathway Diagram (CPD), this study seeks to provide a comprehensive and “blueprint” framework for understanding how implementation strategies operate through specific mechanisms to influence implementation determinants and outcomes. The use of CPDs is increasingly recognized as a valuable approach to explicitly articulate the hypothesized causal links between implementation strategies, their underlying mechanisms of action, and subsequent outcomes (7, 20, 23, 24). These diagrams can also incorporate Behavior Change Techniques (BCTs) - the active ingredients within implementation strategies that are theorized to drive change. Resources such as the Behavior Change Technique Taxonomy (BCTTv1) and the Theory and Techniques Tool aim to facilitate the specification of BCTs (23, 25–28).

We validate the proposed methodology by applying it in the context of an implementation research project currently running in a Swiss University Hospital and aiming to implement a computerized decision support system (CDSS) for the early detection of hospital-acquired pressure injury (HAPI). This article specifically details the methodology employed during the pre-implementation phase and outlines the entire process within the context of this research project.

Methods

Sample and setting

This example is drawn from a multi-method, cross-sectional study conducted between January 2024 and February 2025, in the traumatology unit of a Swiss University Hospital. An implementation team was established within the unit using a rational choice sampling approach. Aligned with the CFIR roles subdomain, the team comprises three mid-level leaders (Nurse Manager [NM]), one opinion leader (Clinical Nurse Specialist [CNS], two implementation facilitators (Nurse [RN] and Health and Community Care Assistant [HCCA]). All team members also served as deliverers of the innovation, the use of the CDSS (3). The implementation team members were consistently informed, consulted, and involved in decision-making throughout each phase and step of the study. These team members also served as the participants for the contextual analysis. Inclusion criteria for the healthcare professionals were being part of the unit's healthcare team. Exclusion criteria were being an interim RN. The healthcare professional's population consisted of all healthcare team members within the unit. The patient population included inpatients 18 years and older hospitalized in the unit between January 1st, 2024, and December 31, 2024.

Overview of the methodology

The methodology is based on the CPD (7,20,23). CPDs are practical visual tools that enable researchers or practitioners to represent and evaluate their hypotheses on how implementation strategies work, by identifying causal links between determinants, mechanisms of action, and expected implementation outcomes (7,20,23).

The methodology is structured in seven steps: 1) implementation determinants are identified; 2) the identified determinants are prioritized; 3) implementation antecedents are assessed; 4) the mechanisms of action of strategies to address antecedents are identified and understood; 5) implementation strategies adapted to the context are identified; 6) these strategies are prioritized; and 7) implementation strategies adapted to the context are developed (Figure 1).

[Insert Figure 1 here] Figure 1. Overview of methodology guided by Causal Pathway Diagram (CPD) adapted from Klasnja et al. (23).

Step 1: Determinants of the implementation

Data collection

Data collection was guided by the CFIR 2.0 constructs (3). Qualitative data were collected by the principal investigator (SP) and the research collaborator (ADB) through CFIR card game session with the implementation team (29). The card game consisted of 26 cards, each corresponding to one of the 26 CFIR constructs that had been translated into French and simplified. The process of simplification involved translating technical terminology into clear, direct language understandable to healthcare professionals, while ensuring the fundamental meaning of the construct was preserved, in accordance with the work of Pellet et al. (30). For each card, it had to be determined by the implementation team members whether it was: 1) a barrier or a facilitator; 2) modifiable or non-modifiable; 3) highly influential or not very influential, and a consensus had to be reached. During the session, the principal investigator was the facilitator, guiding discussions and ensuring all participants had the opportunity to contribute. Responses, comments, and observations were recorded on a CFIR card game recording sheet by the research collaborator (29). The session was audio-recorded to ensure accurate data capture.

Data Analysis

A rapid qualitative analysis, according to the methodology describe by Nevedal et al. in 2021, was conducted (31). The qualitative data collected during the CFIR card game session were analyzed during meeting with participants following the consensus process. The CFIR card game recording sheet served as a primary tool for this analysis. Audio recordings were used by the second research collaborator (ChM) to supplement the notes taken during the session, specifically to clarify ambiguities or expand upon essential points; however, full transcription was not conducted. This pragmatic approach was appropriate because the objective was not to conduct an in-depth thematic analysis, but rather to validate and prioritize the determinants using the participants' consensus. This approach balanced the need for detailed data with the practical constraints of time and resources. Audio recording was used to

ensure the accuracy of the decisions. These findings were then reformulated and used by the principal investigator and research collaborators to prepare the next step.

Step 2: Priority determinants of the implementation

Data collection

Consensus meeting with implementation team members were then conducted by using the Nominal Group Technique (NGT) (32–34). This method will allow the participants' involvement in the implementation process and achieve a consensus about the priority of each modifiable and highly influential determinant identified during the CFIR card game session. Each member of the implementation team rated the priority level of each determinant on a scale from zero to ten. Then, an average score was calculated and discussed within the team. The principal investigator (SP) and the research collaborators (ADB, ChM) were facilitator and observers during the session. The session was audio-recorded, and notes were taken.

Data Analysis

Quantitative data from the NGT sessions were analyzed during the session to calculate mean scores for each determinant, enabling prioritization. All determinants with a score higher than five were considered priorities. Qualitative data collected during the consensus meeting were analyzed collaboratively with participants. Like Step 1, audio recording was used to supplement session notes for clarification and detail, without full transcription. A rapid qualitative analysis was conducted (31). The rationale and limitations of this approach are consistent with those described in Step 1. The CPD determinant part was completed (Figure 1).

Step 3 : Antecedents of implementation

Data collection

The Implementation antecedents are the acceptability, the appropriateness, the feasibility, the implementation climate, and the implementation readiness (19). To assess the antecedents of implantation, the qualitative data collected during the CFIR card game session (Step 1) and the consensus meeting (Step 2) were used.

To provide more comprehensive contextual understanding, quantitative aggregated data were extracted from the hospital Datawarehouse and electronical health records (EHR). This extracted data included patients' characteristics, staffs' characteristics, and units' characteristics. These data represent contextual factors related to the innovation, inner setting, and individuals' domains of the CFIR 2.0 (3).

Data Analysis

A deductive qualitative analysis, informed by the CFIR 2.0 and the CFIR outcomes addendum (3,19) was conducted. The principal investigator and research collaborators performed a CFIR-directed content

analysis with the notes and audio recordings. The principal investigator and the research collaborators coded the notes and recorded quotes. The CFIR 2.0 constructs and the antecedent of implementation according to the CFIR outcomes addendum were used for coding (19). The notes were categorized using the definitions of preconditions and moderators from the research of Klasnja et al. (23). A precondition is a necessary factor for a determinant to influence an implementation outcome. A moderator is a factor that modifies the strength of a determinant's influence (23). Data were categorized as preconditions if the response to the question, "Does the absence of this element block the determinant from influencing the antecedent?" was affirmative. In other words, without this element, the determinant cannot act as a lever to promote the antecedent of implementation and, thus, the implementation outcome. Data were considered moderators if the answer to the question, "Does this element modify the strength of the determinant's influence on the antecedent?" was affirmative. Then, the quantitative data were integrated to support this analysis. The results will be compared and discussed between the researchers (ADB, ChM, CM, SP) during meetings. The findings were then presented to the implementation team for triangulation and validation. Following validation, the CPD was completed (Figure 1) integrating both qualitative and descriptive quantitative data.

Step 4: Mechanisms of Actions

Data Collection

The data collected for this step were the findings of previous steps validated by the implementation team.

Data Analysis

First, an inductive qualitative analysis was conducted based on the results of previous steps. The objective was to identify mechanisms for addressing the priority determinants. One or more mechanisms formulated for the context of the study were identified for each priority barrier or facilitator. The mechanism part of the CPD was completed (Figure 1). Next, a deductive qualitative analysis informed by BCT theory was conducted (28,35). For each mechanism identified, the principal investigator then made the link with the 26 MoAs in the BCT Theory and Techniques Tool (36). The results were then discussed and triangulated among the researchers (ADB, ChM, CM, SP). To facilitate understanding of the mechanisms, they were simplified, reformulated, and then presented to the implementation team for validation.

Step 5: Implementation strategies selection

Data Collection

The data collected for this step were the findings of step 4, validated by the implementation team.

Data Analysis

Implementation strategies were identified based on the priority determinants and mechanisms identified in the previous steps. The Theory and Techniques Tool was used to identify the BCTs associated with each MoA (25). The BCTs were then translated into implementation strategies from the ERIC compilation of implementation strategies based on the work of McHugh et al. (12). Each BCT identified above was associated with one or more strategies.

A simplification process was then carried out using the strategy definitions to identify those that were already in place, those that related to the research team only, and those that related to the implementation team and the unit team. This resulted in a list of implementation strategies adapted to the unit.

Step 6: Implementation strategies Prioritization

Data collection

The list of adapted implementation strategies was reformulated for the context and presented to the implementation team. Consensus meeting with implementation team members was then conducted by using the NGT (32–34). The principal investigator (SP) and the research collaborators (ADB, ChM) were facilitators and observers during the session. The session was audio-recorded, and notes were taken. The findings of this meeting prioritized the implementation strategies.

Data Analysis

Quantitative data from the prioritization session were analyzed during the meetings, with mean scores calculated for each strategy to determine priority. Qualitative data from the consensus meeting were analyzed collaboratively with participants. As in previous steps, audio recordings were used to supplement session notes, focusing on clarification and key details, without full transcription. The rationale and limitations of this approach remain consistent with those previously described. The implementation strategy and precondition parts of the CPD was then completed (Figure 1).

Step 7: Implementation Strategies Development

Data Collection

For this step, the collected data were the findings of step 6, and the notes and audio-recordings of steps 1, 2, and 6.

Data Analysis

Based on the priority strategies previously identified by the implementation team, strategy bundles were developed. Each priority strategy (those with a score > 5) was defined and specified according to Proctor et al.'s 2013 recommendations (37) and tailored to the specific context of the traumatology unit. The strategies were then rated using the APEASE criteria (38) to assess their acceptability, practicability, effectiveness, affordability, safety, and equity. These strategy packages were then presented to the

implementation teams for validation. An implementation protocol was established and actively monitored during the implementation phase, allowing for ongoing adaptation and refinement of the strategies as needed.

Ethical considerations

This research involved anonymously collected or anonymized health-related data. The Federal Act on Research involving Human Beings (Human Research Act, HRA) did not apply to this research (Art. 2, Section 1, Chapter 1, HRA). This study was approved as an improvement project by the hospital's legal department and the internal research evaluation board (CEDE: Commission d'Évaluation des Demandes d'Enquêtes, registration number: 89.2023).

Results

To view the methodological process and promote understanding, a synthesis of results is reported in Figure 2. For clarity, only part of the results is presented for each step.

[Insert Figure 2 here] Figure 2. Synthesis of results.

Step 1: Determinants of the implementation

During the CFIR card game session, among the 26 CFIR constructs assessed, the implementation team identified the construct Motivation from the domain of individuals like a barrier which was modifiable and with strong influence. The explication of the construct on the card was "The individuals involved in the implementation of [name of the innovation] are committed to fulfilling their roles". The implementation team members explained their choice by pointing toward the fact that motivation among healthcare team members depended on their awareness and involvement in HAPI prevention (Figure 3).

Step 2: Priority determinants of the implementation

After consensus meeting using NGT, the CFIR construct Motivation was a priority with a mean score at 9.8 (Figure 3). The implementation team members explained the prioritization, saying that many healthcare team members wouldn't be motivated because they wouldn't see the need for this innovation. They believed motivation would depend on how the HAPI's issue and prevention were perceived. They said it would be necessary to support individuals by considering each person's level of awareness.

Step 3 : Antecedents of implementation

The implementation readiness refers to "the extent to which the internal environment is ready for implementation" (19). For the implementation team, the implementation readiness was unfavorable. "For the moment, lack of information for the team, the team is not ready." The motivation was linked to the unreadiness.

The implementation team emphasized prior awareness of the issue and prevention of HAIs as necessary factors for motivation to promote implementation readiness (precondition). During the study period, the HAI rate was 1.0%, and the Braden score was used to assess risk at least once by 81.43% of patients during hospitalization. Of these patients, 67.67% were at HAI risk. Approximately 65% of patients at risk had benefited from at least one preventive measure during their hospitalization.

According to the implementation team, the link between motivation and implementation readiness would be strengthened if healthcare team members received support tailored to their skill levels. The skill mix during this period was 75%, with the healthcare team consisting of three-quarters nurses and one-quarter nursing assistants and health and community care assistants (Figure 3).

Step 4: Mechanisms of Actions

Based on the findings of the step 3, three mechanisms for addressing the motivation determinant were identified. For this example, only one mechanism will be detailed (Figure 3).

In step 3, a precondition for motivation to promote readiness was awareness of the issue and prevention of HAIs. One of the underlying mechanisms to achieve this would be to make visible existing knowledge, abilities, and skills regarding the issue of HAIs and their prevention. Data extraction revealed that approximately 18% of patients did not undergo risk assessment using the Braden scale, and approximately one-third of patients at risk did not receive preventive measures. Using the innovation would enable us to assess risk for all patients and take appropriate preventive measures. In line with BCT theory (28,36), this mechanism could enable users to become aware of the issue of HAI and of the innovation (BCT MoA: Knowledge), believe in their ability to prevent HAI and use the innovation (BCT MoA: Beliefs about Capabilities), and their consequences (BCT MoA: Beliefs about Consequences), and emphasize the skills and competencies acquired through practice (BCT MoA: Skills).

Step 5: Implementation strategies selection

After validation of the mechanism by the implementation team, the four MoAs linked were associated to 20 BCTs according to the BCT Theory and Techniques Tool (36). Then, based on the work of McHugh et al. 2022 (12), 17 potential ERIC strategies were identified to activate the mechanism. Among the 17 strategies, six were related to the research team and already in place, and one was not applicable. Finally, 11 strategies related to this mechanism were presented to the implementation team.

To simplify the process description, only one BCT and one associated strategy will be presented in this example. The BCT “8.1 Behavioural rehearsal” was linked with two BCT MoAs: Skills and Beliefs about Capabilities (36). According to Mc Hugh et al., this BCT is probably indicated in ERIC strategy: “Model and simulate change” (12). This strategy was presented to the implementation team for prioritization.

Step 6: Implementation strategies Prioritization

After consensus meeting using NGT, the ERIC strategy “Model and simulate change” was a priority with a mean score at 10. According to the implementation team, this strategy would trigger the mechanism if it did not take the form of a video or simulation workshop. Rather, it should take the form of educational or informative material in a simple format, such as a pocket card or poster displayed at the desk, as well as demonstrations at existing meeting points (Figure 3).

[Insert Figure 3 here] Figure 3. Synthesis results of methodological process guided by CPD adapted from Klasnja et al. (23).

Step 7: Implementation Strategies Development

Each priority strategy previously identified by the implementation team, was defined and specified according to Proctor et al.'s 2013 recommendations (37) and to the context (Table 1). According to the APEASE criteria (38), the strategy score was 29 out of a possible score of 30. This strategy was included in a bundle of five strategies integrated in the daily huddles.

[Insert Table1 here]

Table 1. Definition and specification of the strategy “Model and simulate change”

Model and simulate change

Definition	Model or simulate the change that will be implemented prior to implementation
Actor(s)	Research Team – Implementation Team
Action(s)	<ul style="list-style-type: none">• Allow the implementation team and the healthcare team to test the application several times outside of the daily care process + see educational/informative materials• Encourage or advise to imagine and compare the future results of risk assessment and prevention implementation with the innovation vs current practices
Target	Implementation Team – Healthcare Team
Temporality	<ul style="list-style-type: none">• Before the deployment of the innovation in the unit• During the deployment of the innovation in the unit• During existing huddle• During meetings between research team and implementation team
Dose	As much as needed
Implementation outcomes affected	Implementation readiness
Justification	To make visible existing knowledge, abilities, and skills regarding the issue of hospital acquired pressure injuries and their prevention

Discussion

This methodology could address various challenges in the field of implementation science. It responds to the need to establish more explicit links between implementation determinants, strategies and outcomes. It also aims to improve our understanding of the mechanisms by which implementation strategies produce change, going beyond simply identifying effective strategies. Furthermore, its multi-framework and multi-theory approach enables a more comprehensive and nuanced understanding of the implementation process. Additionally, it draws on innovative and effective methods of data collection and analysis, each of which adds significant value. In summary, this study contributes to a more rigorous and theoretically grounded approach to the implementation of evidence-based practices.

Previous studies have highlighted an insufficient understanding of the causal relationships between implementation strategies, determinants, and outcomes (6, 21, 22, 24, 39, 40). This methodology uses CPDs to map determinants, mechanisms, and expected outcomes. This approach enhances transparency, enables hypothesis validation, and identifies key measurement points (7, 20, 23, 41). As emphasized by Klasnja et al., CPDs help professionals grasp causality by examining the processes through which strategies operate, optimizing the match between strategies and barriers, and identifying

conditions for successful implementation (23). This approach operationalizes the shift from "classification to causality" advocated by Lewis et al. and provides a practical means to identify and test the "bridges and mechanisms" described by Luke et al. and the adaptive, mechanism-oriented strategies promoted by Geng et al. (20–22). Integrating multiple frameworks with CPDs ensures both theoretical rigor and practical applicability. Following Proctor et al.'s recommendations for detailed strategy specification improves reproducibility and comparability (37). The methodology, grounded in BCT theory, identifies MoAs as the active components that drive change (28, 36). Links between BCTs and MoAs, provide a foundation for testable causal models that can be refined over time. Due to the lack of empirical studies that establish causal links between strategies, mechanisms, and outcomes, this methodology provides a structured, theory-informed, and empirically testable approach to advancing research and guiding the adaptation of implementation strategies in different contexts.

This methodology is based on the synergistic integration of proven-effective frameworks, theories, and taxonomies in implementation science. This multi-framework approach is a significant asset because it provides a more comprehensive and nuanced understanding of the implementation process. As Nilsen and Moullin et al. have noted, employing theoretical frameworks to direct study design, stimulate theoretical and empirical reasoning, and streamline result interpretation is paramount. These frameworks facilitate the development of a shared language and provide practical tools for planning, executing, and evaluating implementation efforts (42, 43). The present methodology addresses the tendency among implementation science researchers to specialize in a single research approach. The present methodology integrates CFIR, ERIC, BCT, and IOF to promote an interdisciplinary approach. This approach enhances the integration and comparison of methodologies, thereby reinforcing the discipline (42, 43). Integrating these frameworks and theories helps define the objective of the implementation effort and prioritize the determinants to be targeted. This is of paramount importance when considering funding and resource limitations (42, 43).

This methodology incorporates innovative and efficient data collection and analysis methods that add substantial value. The CFIR card game is an interactive, qualitative tool that facilitates the identification of determinants. Translated and simplified CFIR constructs make it accessible to healthcare professionals without specialist implementation knowledge (30). When used alongside the NGT, a structured consensus method that minimizes dominance effects and ensures equal participation, this approach enables the prioritization of determinants and strategies based on feasibility and perceived importance (33–35). Following Nevedal et al.'s methodology, rapid qualitative analysis used notes and audio recordings rather than full transcripts, reducing time and cost while maintaining rigor (31). Despite requiring expertise in qualitative methods and CFIR, this near real-time analysis was essential for timely decision-making during implementation. Combining multiple methods yielded rich, diverse data, and triangulation enhanced the validity of the results.

This methodology is characterized by its complex, structured design that integrates multiple stages and theoretical frameworks from implementation science. This approach generates generalizable knowledge and robust theories. While this level of rigor provides valuable insights, it requires significant resources,

including time, skilled facilitation, and sustained stakeholder engagement, and may be difficult to maintain in pragmatic or resource-limited contexts. However, the process can be adapted without losing its core logic. For example, one can focus on the most relevant CFIR constructs, streamline data collection through shorter or asynchronous formats, leverage existing data, or condense CPD mapping into a single session. A CNS can play a pivotal role in these adaptations by coordinating the identification of priority determinants, facilitating consensus, and integrating simplified CPD mapping into existing governance or quality improvement meetings. This approach maintains methodological fidelity while alleviating the burden on external teams. This balance between rigor and feasibility enables the development of context-tailored strategies, demonstrating how structured adaptation can render the "art" of implementation more systematic and less dependent on intuition.

Stakeholder involvement is critical to the success of implementation projects, and this methodology emphasizes active engagement throughout the process. Using the CFIR card game (29) and consensus meetings via the NGT (33, 34) ensured that field perspectives informed the development of strategies at every stage, thereby reinforcing their relevance and acceptability. Stakeholders provided valuable insights into workflows, infrastructure, culture, resources, and challenges. This enabled the co-design of contextually appropriate solutions, as advocated by Kirk et al. (13). Although this approach relies on research expertise, it also incorporates practical experience to ensure strategies are theoretically sound and operationally feasible. Intensive engagement demands substantial time and resources but enhances credibility, fosters ownership, and improves implementation outcomes. The facilitator plays a pivotal role in sustaining this engagement. In our case, the principal investigator's pre-existing relationship with the team strengthened trust, but it also posed a risk of social desirability bias. This risk was mitigated through iterative consensus-building, triangulation, and validation.

Conclusion

While the complexity and specific context of this case study require cautious interpretation of the findings in terms of generalizability, the proposed methodology provides a structured and participatory framework for developing contextually appropriate implementation strategies, with an emphasis on understanding mechanisms of change and stakeholder engagement. This approach could be useful in advancing the science of implementation by providing a detailed model for linking theory to practice.

Abbreviations

BCT: Behavior Change Technique

BCTTv1: Behavior Change Technique Taxonomy

CDSS: Computerized Decision Support System

CFIR: Consolidated Framework for Implementation Research

CNS: Clinical Nurse Specialist

CPD: Causal Pathway Diagram

EHR: Electronic Health Record

ERIC: Expert Recommendations for Implementing Change

HAPI: Hospital-Acquired Pressure Injury

HCCA: Health and Community Care Assistant

IOF: Implementation Outcomes Framework

MoA: Mechanism of Action

NGT: Nominal Group Technique

NM: Nurse Manager

RN: Registered Nurse

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Conceptualization: SP, JLR, and CM. Methodology: SP and CM. Data collection: SP. Project administration & data curation: SP and CM. Formal analysis: SP. Validation: JLR and CM. Writing – Original Draft: SP. Writing – Review & editing: JLR and CM. All authors read and approved the final manuscript.

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Figures

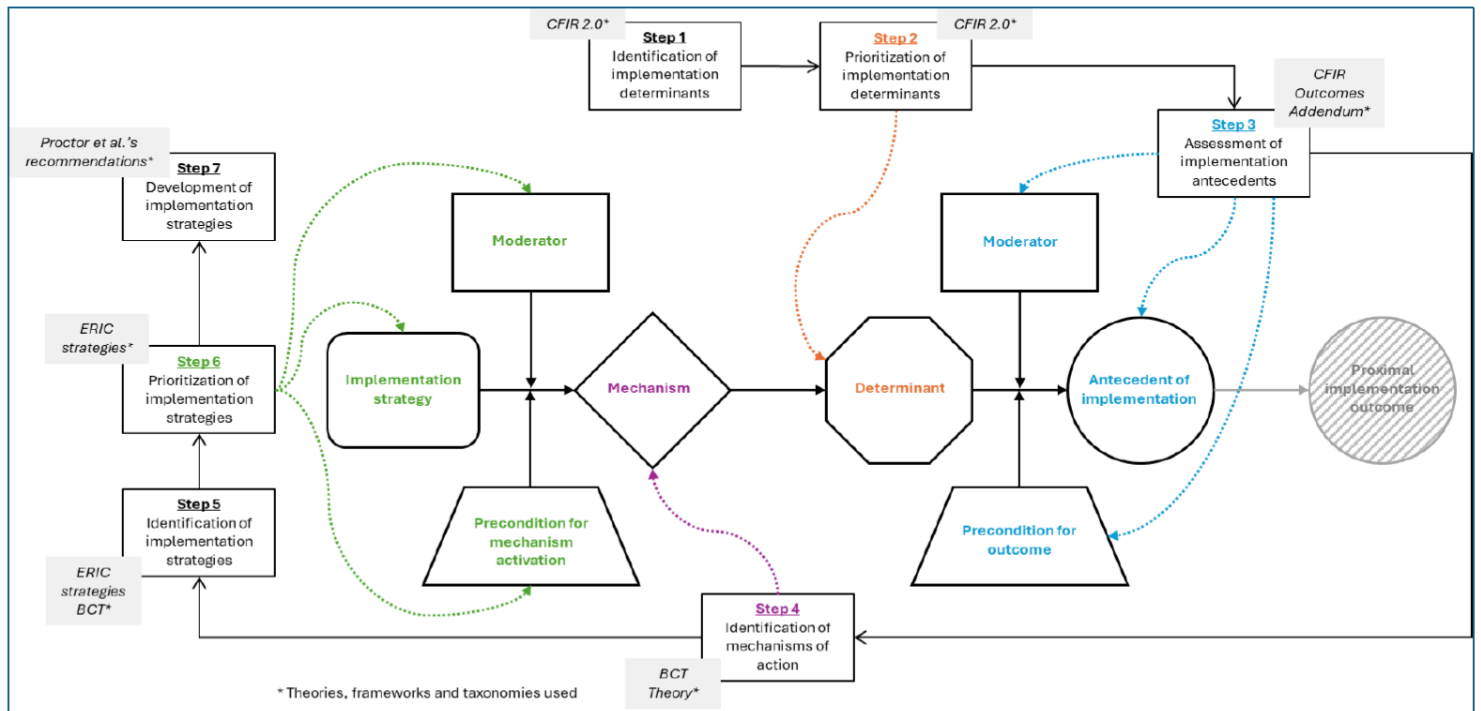


Figure 1

Overview of methodology guided by Causal Pathway Diagram (CPD) adapted from Klasnja et al. 2024

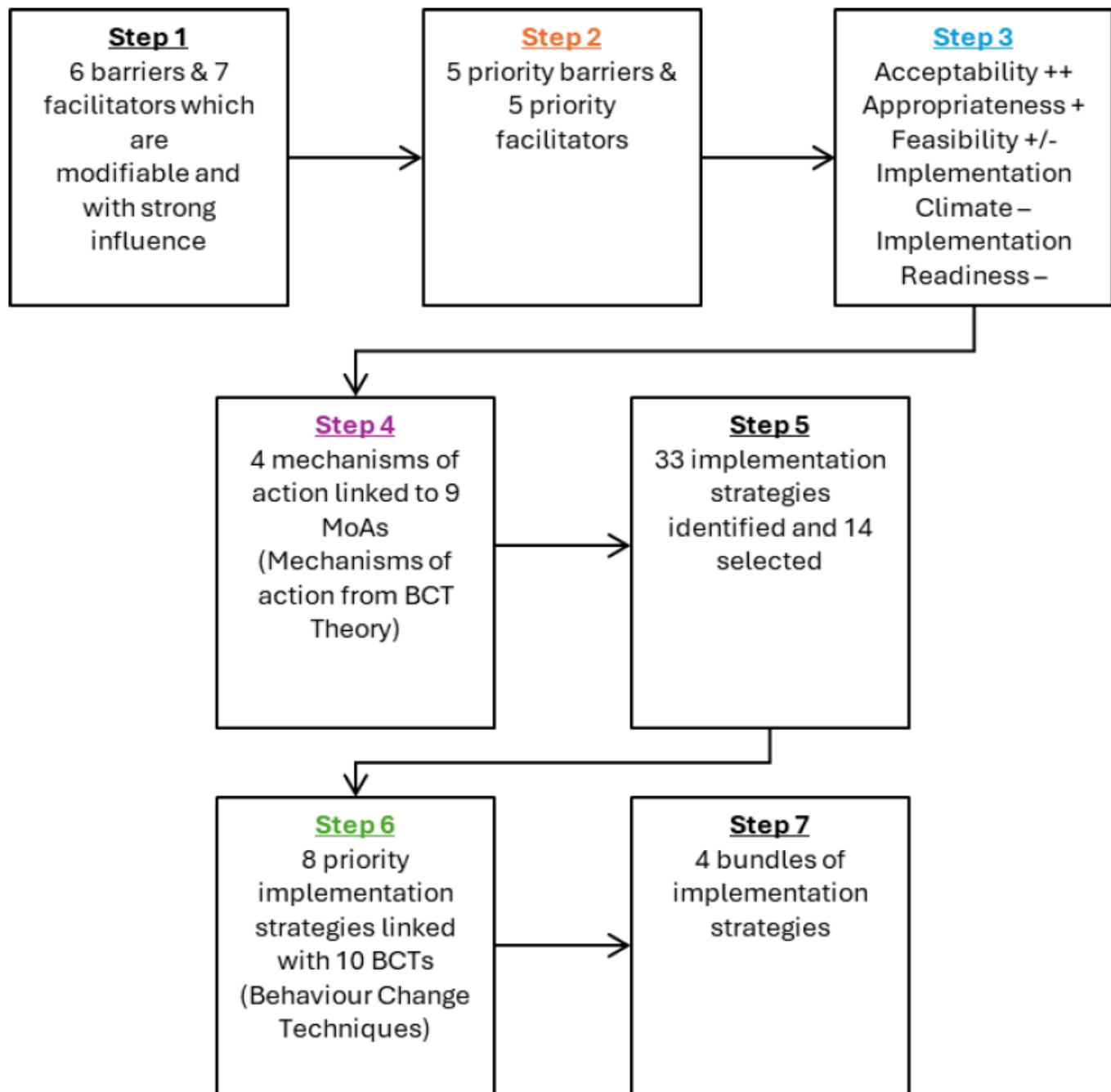


Figure 2

Synthesis of results

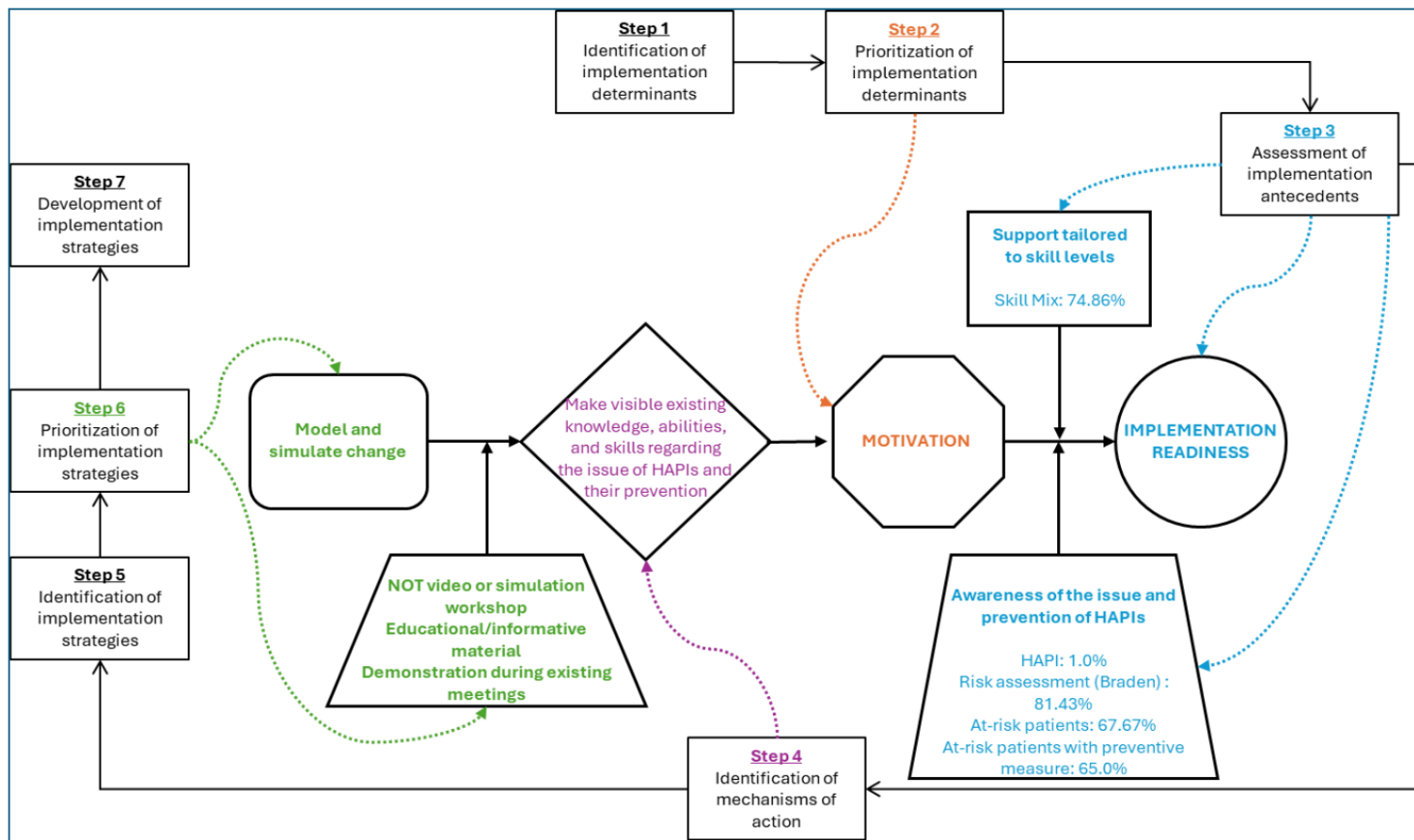


Figure 3

Synthesis results of methodological process guided by Causal Pathway Diagram (CPD) adapted from Klasnja et al. 2024

Supplementary Files

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- [SupplementaryMaterialAdaptedStaRiChecklist.pdf](#)