
Review

Making Decision-making Visible- Teaching the Process of Evaluating Interventions

Angela Benfield^{1*} and Robert Krueger²

¹ University of Wisconsin-La Crosse, abenfield@uwlax.edu

² Whitworth University; rkrueger@whitworth.edu

* Correspondence: abenfield@uwlax.edu

Abstract: Significant efforts in the past decades to teach evidence-based practice (EBP) implementation has emphasized increasing knowledge of EBP and developing interventions to support adoption to practice. These efforts have resulted in only limited sustained improvements in the daily use of evidence-based interventions in clinical practice in most health professions. Many new interventions with limited evidence of effectiveness are readily adopted each year - indicating openness to change is not the problem. The selection of an intervention is the outcome of an elaborate and complex cognitive process which is shaped by how they represent the problem in their mind and is mostly invisible processes to others. Therefore, the complex thinking process which support appropriate adoption of interventions should be taught more explicitly. Making the process visible to clinicians increases the acquisition of the skills required to judiciously select one intervention over others. The purpose of this paper is to provide a review of the selection process and the critical analysis that is required to appropriately decide to trial or not trial new intervention strategies with patients.

Keywords: evidence-based practice; clinical reasoning; causal model; intervention theory; Concept Mapping

1. Introduction

All health professions have mandated the use of evidence-based practice (EBP) as a tenet of ethical practice[1] as it is known to improve healthcare quality, reliability, and client outcomes[2; 3]. Over the last twenty years, skills and knowledge have significantly improved [4]and a great deal of effort (as well as the development of the fields of implementation science and knowledge translation) has gone into increasing the use of evidence-based practices (EBPs) in by clinicians. However, all of these efforts have resulted in limited sustained behavior change for implementing EBPs[4; 5]. All agree that appropriate implementation of EBPs is challenging due to a variety of factors. However, the theoretical ‘causes’ of this is due to low EBP skill [4], organizational climate[6], and lack of ‘openness’ to change practice[7]. However, there is no evidence that willingness to change practice is a causal factor as no studies have specifically measured the frequency of adopting new interventions; instead, most studies probe the adoption of specific interventions of interest (e.g., Locke et al., 2019). On the contrary, evidence suggests that openness to adoption of new interventions is not the problem as “fad” interventions continue to be reported in many areas of healthcare [9-11]. Most professionals report learning about new interventions from peers and rely on experience to select which ones to use in practice [12-16]. Importantly, it is the professional’s opinions on the intervention alternatives which most highly influence the client’s preference for action [17].

Second, we agree that some EBPs, such as handwashing for reducing infection, need to be implemented in all settings. However, not all interventions should be assumed to be the correct action in all settings with all clients. It is important to note that some EBPs can be adopted as written, some may need to be modified in a specific context or with a specific patient, and some will not be appropriate for adoption at all. Appropriate implementation of any given intervention is therefore dependent on many factors including the confirmation that the clients are members of the same population as the sample from the intervention study being considered for adoption to practice. Frequently, the descriptions of whom the EBPs is directed provides insufficient information to determine if that the client is a member of the population [14; 15]. Importantly, EBPs are often developed using evidence from randomized controlled trials (RCTs) [14]. However, the features of RCTs are such that increasing internal validity often leads to decreased external validity as appropriate application requires significantly more information about the participants, settings, and intervention than what is typically available in a published study. Registries (e.g., clinicaltrials.gov) and manualized interventions are two strategies developed to address the generalizability difficulties of clinical trials. These strategies support the clinician in assessing generalizability by providing rich information on the participants, settings, and characteristics of the interventions used [18-20]. However, difficulties remain due to insufficient information [21]. Most interventions are complex, with many elements included in the intervention application. Many EBPs provide limited clear understanding of which intervention components are required activities (i.e., active ingredients) and which are not (i.e., inert ingredients). Therefore, partial implementation may result in the same outcome without doing all intervention components [22]. In other words, appropriate implementation of EBPs can be different across different settings.

Lastly, significant efforts and interventions have been applied in the last twenty years to increase EBP implementation rates. In fact, the field of implementation science main purpose is to identify the methods and strategies that facilitate evidence-based practice and research by clinicians [23; 24]. Importantly, one of the main assumptions underlying this implementation science research is that organizational climate affects implementation rates [6; 25]. Therefore, strategies for increasing implementation of EBPs have targeted decreasing barriers, increasing supports, and increasing cultural expectations [6]. Although we agree these are important variables, we suggest an alternative causal mechanism should be considered. New evidence suggests that organizational climate is not a 'causing' variable, but a 'moderating' factor to EBP implementation [5]. Adoption of new interventions may not be the issue related to low EBP implementation as clinicians report frequently adopting and trialing new interventions with no or low evidence [16; 26]. This suggests that we may need to take a step back and reexamine how we are defining and attempting to solve the problem of low implementation. We suggest that students need to be explicitly taught how to assess their personal causal models and the decision-making process.

2. EBP Curricula

We agree that the development of various EBP curricula has led to better skills and knowledge of how to appraise and synthesize evidence to support local practice. These curricula have taken a complex, multistep process and made it easier by directly teaching the specific action steps which the clinicians are expected to do (e.g., Ask, Identify, Appraise, Apply, Evaluate). Further, appraisal systems and tools (e.g., GRADE, CASP, Cochrane)

decrease cognitive load by providing cues or reminders on questions which need to be answered. More elaborate systems, like GRADE, even provide decision trees to decrease the chance of making an error. Importantly, the EBP process, appraisal systems and decision-support tools have been demonstrated to improve the positive impact on the quality of the care and clinical outcomes as they increase the likelihood of the correct decision being selected and enacted [1]. However, the decision-support tools typically are only available to address clinical questions where there is more certainty (e.g., differential diagnosis decision-making of known problems, depression medication choice, statin choice [<https://carethatfits.org/>]) and sufficient evidence to develop EBP activities. Critically, many of the intervention decisions are made in uncertain conditions [1], which lack strong, un-equivocal evidence that there is only one correct action.

3. Problem Solving in Medicine

Since the Renaissance, science and medicine were rooted in the assumption that if problems are divided into smaller and simpler units, they become easier to solve [27]. These smaller units lent themselves to linear causality, e.g., one cause produces one effect [28] and heavy reliance on linear diagrams and flow charts [29]. Recently, support has been voiced for using 'holistic' or systems biological approaches to think about clinical problems: however, many technological advances continue to require increased specialization which reinforce reductionistic approaches [30]. On the other hand, understanding a problem from a dynamic systems approach requires one to examine it from a multidisciplinary approach leading to the mandate of interprofessional care [31]. However, this same push introduces another level of complexity as each specific discipline advocates for their individualized profession's scope of practice, allocation of resources, and different professional definitions of the problem, goal, action steps, and outcome indicators [32]. Modern healthcare services are consistent with the blind men and elephant parable. Each profession uses their own professional paradigm, experiences, and client interactions to frame and solve the client problem. Importantly, it is more likely that each professional will have a different causal model that they are using to organize their knowledge and examine the problem [33]. In fact, even members of the same profession are just as likely to have different mental conceptualizations of the same client that may not be supported by the evidence or formal theories (e.g., professional paradigms) [34; 35]. Critically, integrated knowledge has been implicated as prerequisite for successful problem solving [36; 37] and evidence supports it is the restructuring of knowledge as new information is learned leads to richer causal models which leads to being more likely to select appropriate actions [38].

Evidence on what humans do when presented with a novel problem suggests that heuristic reasoning is used in time limited situations [39] as most people require approximately eleven to sixteen seconds to process, interpret, and formulate an initial reflective response [40]. In medicine and healthcare, heuristics is a strategy which is used when decisions need to be made quickly, as it ignores information as a tradeoff between time available and the cost of getting better information [41]. Fast thinking can be highly influenced by cognitive biases and include ambiguities [42; 43] Actions taken in the past are easier to remember than the actions not taken, [44] or how the problem was initially defined. Importantly, fast thinking (e.g., intuition, heuristics) also highly influence initial seeking and interpretation of information, but also early closure if purposeful conscious thinking efforts are not engaged [45; 46]. One common educational intervention frequently used to slow down closure has been the use of 'think aloud' during which the respondent describes their evidence, making their thinking visible to communication partners [39]. This

allows all involved to have more time to reflect on the quality of the judgment and to compare evidence to their own reflective thinking process [39]. However, 'think aloud' was not a solution for all difficulties. Reflective practice and EBP frameworks were developed to best address limitations in decision-making and heuristic reasoning. Both strive to increase critical reflection and integration of non-experiential evidence into the decision-making process [45]. There is general consensus that thinking changes with experience and expertise [47-56]. One benefit of this change is that experienced clinicians often recognize similar situations (e.g., familiar problems) more quickly [57]. Importantly, experience may not improve their ability to adapt commonly used strategies to resolve new problems or increase their ability to recognize errors in their own thinking processes [39; 58-60]. Since heuristics will always have a role in decision-making due to the speed of expected in real-time interactions, it is important to understand what information is used in heuristic decision-making.

3.1 Heuristics and Causal models

In everyday life, adaptive response is the outcome of rapid decisions based on numerous different interrelated variables [61; 62]. In any given situation, we identify the variables which we believe are 'causing' or influencing the current situation [61-63]. In other words, decision-making is not linear, but a dynamic process, where there are many alternative options for achieving an outcome [61]. Interestingly, there is strong consensus that the clinician's beliefs about clinical problems are probabilistic and are weighted in the causal model by how likely any individual variable is believed to be causing or influencing the outcome [1], consistent with Bayesian inference [64]. Importantly, these mental models represent a person's theory of how the world works and also include estimations of their probabilistic relationship of the variable to the situation and the desired outcome [27; 62]. Clinicians use their mental model to select the actions that their personal theory posits as the most likely to achieve the desired outcome given a specific situation. Significant evidence supports that it is this mental model which drives intuitive and heuristics decisions [65-68]. Deliberate practice and EBP were specifically targeted to support clinicians in solving problems as they emerge. We agree that these models for supporting practice are important and should not be discounted. However, professional education curricula need to directly teach students how to think about their thinking, appraise their knowledge, and how to integrate of information into rich evidence-informed causal models. Importantly, we also posit that by clearly teaching this skill as an expectation for ethical practice, completed (at least informally) when new information is learned, it significantly increases the expectations of how frequently they should engage in these activities.

3.2 Causal Models and Interventions

Ideally, each individual clinician relies on their own causal model to select the interventions to use with a specific client [28]. Causal models develop over time as they are the individualized outcome of the clinician's thinking process, synthesizing formal professional theories, lived experiences, and overlying the client's preferences and values related to the problem. Causal models use 'rules' to identify the relationship between the factors, problem, and outcomes which are achievable. The rules develop from professional paradigm, experience, and tacit knowledge. The accuracy of the rules (and their causal model) will depend on how the clinician represents the problem, the number of factors identified, and the factors which are missing. Evidence supports that people's causal judgments can be influenced by observed data when the data is consistent with their mental model; this thinking process is highly

influenced by limited knowledge, missing information or ignored causal assumptions, and cognitive biases [4]. However, making this causal model visible and providing specific strategies (e.g., seeking evidence that the factor is influencing the problem and remediable) increases the likelihood that the causal model correctly weighs the factors which are really causing the problem [11; 17; 62].

3.3 Causal Mapping

Linear thinking leads to erroneous causal assumptions as it relies on the readily available data points (e.g., proximal goal attainment); has difficulty accounting for feedback; and has difficulty accounting for other variables that don't fit in the linear model (e.g., "what if X causes Y, rather than Y causes X, or Z causes Y and X") [6, 42]. Historically, cognitive maps have been used with subjects who have extensive knowledge; however, cognitive maps also have the ability to provide insight into how new information is integrated and synthesized with previous experience and knowledge [3]. Cognitive maps have been used extensively in education as a teaching tool as they reduce cognitive load [50] and encourage deeper learning of concepts by supporting the identification of the relationships between variables [69]. Empirical evidence finds that cognitive maps help students organize the information into a format is retained at higher levels, and allows the learner to encode the information in both visual and language forms (e.g., conjoint retention) [69]. The visual representation of complex relationships is easier to follow compared to relationships between variables being described by words alone, and they foster critical thinking and reasoning [69; 70]. McHugh Shuster (2016) provides an example of how concept mapping helped nurses organize patient care by organizing the patient data, analyzing relationships, establishing priorities, builds on previous knowledge, and encourages a holistic view of the client [71]. Importantly, cognitive mapping has been demonstrated to support EBP uptake [72; 73]. This may be due to integration of the new information into their causal model of the problem [73], which increases the likelihood of an EBP being viewed as an alternative action to achieve the outcome. Importantly, evidence also provides an understanding of how linguistics and analogies, including testimonials, moderate and change an individual's causal model [39], highlighting a critical method which could be used to shift causal models.

3.4 Making Decision Making Visible

The decision of selecting one intervention over others arises out of the intersection of two different critical analysis processes: (1) the personal causal model of the problem and (2) the analysis of interventions. Refer to Figure 1. Simple View of Intervention Selection. The outcome of this process is to select, from all plausible interventions, the one which the clinician believes is the most likely to achieve the outcome given the specific situation and to be able to identify the level of evidence (empirical or theoretical) and confidence of the decision.

Insert Figure 1 near here.

Many of the interventions commonly used in practice have limited evidence of effectiveness [74] and are complex with multiple moderating and affecting variables [75]. The goal of this process is to develop an evidence-informed causal model of the clinical problem which allows the student (or clinician) a deeper and more complex understanding of the theorized causal relationships of the variables. Therefore, this process brings awareness to what, how, and why individuals are thinking. Importantly, this process expands the reasons that one seeks new information as one main purpose is to advance the currency of knowledge with clinical problems which they may address in the future, and expand the integration of knowledge from various sources. The use of expected routines and habits for thinking about practice is from deliberate reflective practice [76; 77] where clinicians respond to triggering events

through a structured process of reflection and critical analysis. In contrast, evidence informed thinking is an expected habit of practice done frequently and routinely - not just when triggering events occur.

In making causal models visible, students are taught the first step when confronted with a problem (e.g., medical condition, clinical problem, culture, spirituality) is to tentatively define the concept or problem and then critically reflect and analyze what they think they know, believe, and value. At this stage, they use their intuition and tacit knowledge to identify variables which they think may be involved. Consistent with the brainstorming stage of problem-solving frameworks, variables are placed on the map without regards to strength or plausibility of its relationship as the goal is to bring to consciousness the variables which may be influencing thinking at later stages. In the third stage, they are explicitly taught to seek and read the literature and talk with peers in order to identify other variables that are theorized or empirically known to influencing the problem. They add the variables and use linking verbs which specifically to identify more variables which people have implicated and to indicate the strength and direction of the relationship (one-way, two-way, or related through other variables)[78]. At this stage, some authors suggest removing concepts which have no relationship[78]. However, there may be benefits to leaving all variables on the map and including the evidence that shows the lack of relationship. This may provide a conscious, visible “nudge” to reflect on why they believe there is a causal relationship and deeper analysis of the phenomena. Importantly, the “lack of evidence” may be due to the lack of data on the relationship, not the lack of a relationship; this, therefore, supports the need for identification and collection of local data to use in outcomes reflection. (Refer to Table 1. Making thinking visible- Evidence-Informed Causal Model). Making Thinking Visible- Evidence-informed Personal causal model of the clinical problem. Importantly, this process is needed to support the deliberate practice models, however, deliberate practice models are not being fully described here for simplicity purposes.

Insert Table 1. Making thinking visible- Evidence-Informed Causal Model

For clinical problems, causal maps provide four specific benefits. First, it makes searching for evidence feasible and more efficient as the variables can become search terms. Second, the factors can be used to identify interventions which are theorized to affect the clinical presentation and the outcome of interest. Third, a causal model in which interventions have been added will contain alternative options for achieving an outcome. Interventions connected to different variables can be inserted into the clinical question (e.g., PICO). In other words, the variables and concepts included on a cognitive map provide starting points for the formal search strategies found in EBP textbooks, which can be a very difficult and frustrating experience for people with limited knowledge of a phenomena. Figures 2-4 provide an example of this process as it relates to handwriting dysfunction in young children. Finally, this process supports the development of evidence-informed causal models and the integration of new information into tacit knowledge by having them add new information as they go through their professional programs and link different cognitive maps together. Using cognitive mapping is consistent with spiral curricula. In spiral curricula, there is a purposeful revisiting of topics whereby each revisit builds on previous knowledge by both deepening their knowledge (and complexity of understanding), but also expanding the connectedness to other knowledge[79]. Using tools such as CMapTools®(<https://cmap.ihmc.us/>), allows for students to actively organize and construct their own maps which also allow them to connect maps together, embed resources, and share maps with others.

Insert Figures 2-4 near here.

As illustrated in the figures, cognitive maps are able to cogently translate information and complex relationships.

3.5 Intervention theory

Many interventions addressing behavioral change are complex, consist of various components which have been combined as they theoretically cause change to important variable affecting the clinical presentation[80] Intervention theory consists of three components: the target that the intervention changes; the mechanism of change, and the components.

Components, or 'ingredients' in intervention theory, include anything which is done by the clinician to a client including, for example, medications, assistive devices, motivational speech, ultrasound, manual touch, instruction, feedback, physical cues. Ingredients target small aspects of the clinical outcome. In practice, interventions contain both active ingredients which are required to inact change in outcome, and inert ingredients which have no effect on the targeted outcome [81; 82]. Identifying the active ingredients can be cost-effective as it reduces time and resource requirements because fewer activities need to be done in order to achieve the outcome[22]. Typically, there is not a clear understanding of which ingredients of an intervention are active[82; 83]. Another reason is that there is a lack of clear identification of all components being applied in the intervention. This is likely to be due to the difficulty in separating the complex relationships between the components when change occurs in dynamic systems[80]. In other words, the form of delivery (when, where, how, how much, who, etc.) is critical to the 'active ingredient'[84]. Therefore, being able to assess intervention fidelity is critical. Fidelity is "the extent to which the core components of a program, differentiated from "business as usual," are carried out as intended upon program enactment" [22](p. 320). Fidelity in studies provides the confidence that it was the intervention that caused the desired effect. Fidelity measures also can be used to differentiate those components more likely to be active ingredients from inert[22]. This is done by comparing the percentage of the components being delivered by the components as defined, and those which are not; this allows assessment of the impact the outcome effects by each component. If the fidelity is low, but equal affects are achieved, the active ingredient is more likely to be one that was causing the change[22].

An example from the clinic on how fidelity tools were used to examine practice is the history of constraint-induced movement therapy (CIMT). CIMT is an intervention which addresses function of a hemiplegic upper extremity. Early protocols called for constraining the uninvolved upper extremity for 90% of the waking hours and intensive therapy for six hours a day, for 10 days over two weeks[85]. However, current understanding of the effects of various treatments for increasing affected extremity function use suggest that CIMT is no more effective than high-dose standard care occupational therapy or dose-matched bimanual therapy, neither of which the "constraining" ingredient is included [86]. This is a great example where assessing local application fidelity to the original protocol allowed clinicians to identify differences in the application of ingredients (including dose, timing, etc.). When consistent outcomes were achieved, it led to significantly reducing time of intensive therapy, using oven mitts (versus expensive "therapy" mitts), and eventually to examining alternative protocols such as bimanual training[87]. Currently, the evidence suggests that these interventions (CIMT, bimanual, and intensive standard care) work due to the dose of the active ingredient, task-specific training[88]. Importantly, research on task specific training research is currently exploring more specific questions (e.g., dose, timing) which critical information is needed to develop effective (and cost-effective) non-burdensome, interventions [89].

One issue with many EBPs, is that the descriptions of the interventions lack a clear explanation of parameters (i.e., what, when, how, or how long) Of any specific activity or component [84; 90]. This 'black box' of intervention components creates a barrier for translation to different contexts and clients[14; 90-92] and explains the commonly reported dependence using peers and what was previously done for selecting interventions[14; 90]. Treatment theory has been proposed as a tool to make intervention selection clearer, make outcomes data more interpretable, and more transferable to different clients and contexts [81; 83; 92]. This process consists of three structures- the *target of the treatment* (e.g., body

function, structure, participation) that is altered by the intervention; *the ingredients* that produce the change; and *the mechanism* that the ingredients cause change in the target of the treatment[81; 83; 91]. This analysis, as well as traditional appraisal of estimates of effect, are what allows for appropriate application of an intervention with a different client and setting[81; 92]. See Figure 5. The Three-part structure of Intervention and Intervention Selection.

Insert figure 5 near here.

3.6 Teaching How to Think about Interventions

We argue that it is important to explicitly teach students what information they should seek when learning about a new intervention. Due to the complexity of information which impacts appropriateness, feasibility, and applicability, the quality indicators for interventions have been identified using suggestions of best practice from a variety of areas: intervention theory, total quality improvement, continuing education effectiveness, clinical reasoning, and EBP. Interestingly, there were similarities across the literature. Appropriate application and increased likelihood of actually selecting an intervention depends on first and foremost, the learner gaining understanding of the problem (e.g., defining) and the need for better client outcomes- in other words, what it typically achieved is less than the potential [80; 83]. This provides the motivation that they need to seek and learn about new interventions, engaging the potential to change behavior[80]. Second, appropriate application is dependent on the learner gaining information about the problem: what interventions (and active components) work, why they work, and any contextual factors which may influence the effectiveness of the intervention[1; 2]. Contextual factors are critical including what components were done, when, where, how and how much[83]. It also includes a discussion of alternative interventions which would be used to weigh plausible different actions[81; 91] as well as the measurement indicators which were used to support differentiation[83; 92]. Importantly, establishing the habit of discussing commonly used alternative helps the learner access their experiential knowledge which can be used to compare client factors, activities, etc.[2]. By having the students use the intervention rubric to reflect on the information provided (from any source) on a specific intervention, reduces the cognitive load and encourages asking (seeking) for needed information. It also supports the students process of identifying when there is a lack of evidence (empirical or theoretical), lack of causal mechanism, and/or lack of clearly identifying data points that would indicate change. See Appendix A. Intervention Rubric.

3.5.1 Clinical Example of intervention analysis

By the mid-1990s, auditory integration training became a world-wide popular intervention for people with autism. It was theorized to improve many person factors such as attention span, eye contact, tantrums, etc. Due to its prevalent use, multiple efficacy studies were completed which found that the intervention had no effect [93]. However, by the time Cochrane Collaboration issued its findings, the original intervention attributed to Berard (1993)[94] had been modified and adapted into multiple interventions with new names (e.g. Tomatis method (<https://www.tomatis.com/en>), (<https://soundsory.com/samonas-sound-therapy/>), Listening Program (<https://advancedbrain.com/about-tlp/>), Therapeutic Listening (<https://vitallinks.com/therapeutic-listening/>), etc.)[95]. Importantly, it is only through an analysis of the critical aspects of the interventions, that a clinician becomes aware that the new interventions use the same treatment theory. Differences (e.g. name, type of headphone, location to purchase music, etc.) appear to be only surface changes. Therefore, the evidence as appraised by Sihna et al., (2011), would suggest that all of these new interventions would also lack of evidence effectiveness. Importantly, these new iterations of auditory integration intervention continue to be used by clinicians. Though, the developer now target a different audience (e.g., occupational therapists, educators, and parents). Interestingly, the information readily available on the interventions is limited but located on highly attractive websites which present powerful narratives of client change by people the vary people who have financial incentives to sell the tools of the intervention. Importantly, none of the newer iterations clearly provide

specific examples which support viewing them as having a different theory of causal mechanism from the studies that showed no effect[95].

4. Conclusion

In order to select the best intervention, it is essential that the clinician use an evidence-informed causal model and has appropriately integrated information on many different variables. Evidence supports that making the complex thinking process visible supports deep learning and improves the causal reasoning which is used to predict which intervention option is best. Expanding our instructional methods to include direct instruction (making thinking visible) has the potential to improve the accuracy of decisions, and therefore, client outcomes, as it supports the development of underlying thinking habits of clinicians. Importantly, intervention selection and EBP are both highly influenced by the clinician's causal model. Therefore, improving the quality and habits of thinking has the potential to increase the likelihood of selecting the "best" interventions with our clients. Specifically teaching and helping students to establish the habit of developing an evidence-informed causal model has the potential to improve heuristic decision-making as evidence suggests that one's causal model highly influences heuristic decision-making. Using cognitive support tools such as the Intervention rubric (Appendix A) also has the potential to improve appropriate selection of interventions by encouraging deeper analysis of interventions and identifying measurement data points that can be used to assess the accuracy of the information used to select it. Using cognitive mapping, specifically causal modeling, also supports the EBP process by highlighting alternative terms and interventions strategies to use in the EBP process.

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Appendix A. Intervention Rubric

References

- [1] Lehan E, Leahy-Warren P, O'Riordan C et al. (2019) Evidence-based practice education for healthcare professions: an expert view *BMJ Evid Based Med* 24:103-108 doi:10.1136/bmjebm-2018-111019
- [2] Melnyk BM, Fineout - Overholt E, Giggelman M et al. (2017) A test of the ARCC© model improves implementation of evidence - based practice, healthcare culture, and patient outcomes *Worldviews on Evidence - Based Nursing* 14:5-9 doi:<https://doi.org/10.1111/wvn.12188>
- [3] Wu Y, Brettle A, Zhou C et al. (2018) Do educational interventions aimed at nurses to support the implementation of evidence-based practice improve patient outcomes? A systematic review *Nurse Education Today* 70:109-114 doi:<https://doi.org/10.1016/j.nedt.2018.08.026>
- [4] Saunders H, Gallagher - Ford L, Kvist T et al. (2019) Practicing healthcare professionals' evidence - based practice competencies: An overview of systematic reviews *Worldviews on Evidence - Based Nursing* 16:176-185 doi:<https://doi.org/10.1111/wvn.12363>
- [5] Williams NJ, Ehrhart MG, Aarons GA et al. (2018) Linking molar organizational climate and strategic implementation climate to clinicians' use of evidence-based psychotherapy techniques: cross-sectional and lagged analyses from a 2-year observational study *Implementation Science* 13:85 doi:<https://doi.org/10.1186/s13012-018-0781-2>
- [6] Melnyk BM (2016) Culture eats strategy every time: What works in building and sustaining an evidence - based practice culture in healthcare systems *Worldviews on Evidence - Based Nursing* 13:99-101 doi:<https://doi.org/10.1111/wvn.12161>

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- [7] Aarons G (2004) Mental health provider attitudes towards adoption of evidence-based practice: the Evidence-Based Practice Attitudes Scale (EBPAS) *Mental Health Services Research* 6:61-74. doi:<https://doi.org/10.1023/B:MHSR.0000024351.12294.65>
- [8] Locke J, Lawson GM, Beidas RS et al. (2019) Individual and organizational factors that affect implementation of evidence-based practices for children with autism in public schools: a cross-sectional observational study *Implementation Science* 14:1-9 doi:<https://doi.org/10.1186/s13012-019-0877-3>
- [9] Konrad M, Criss CJ, Telesman AO (2019) Fads or Facts? Sifting Through the Evidence to Find What Really Works *Intervention in School and Clinic* 54:272-279 doi:10.1177/1053451218819234
- [10] Goel AP, Maher DP, Cohen SP (2017) Ketamine: miracle drug or latest fad? *Future Medicine*. doi:<https://doi.org/10.2217/pmt-2017-0022>
- [11] Snelling PJ, Tessaro M (2017) Paediatric emergency medicine point-of-care ultrasound: Fundamental or fad? *Emerg Med Australas* 29:486-489 doi:10.1111/1742-6723.12848
- [12] Scurlock-Evans L, Upton P, Upton D (2014) Evidence-based practice in physiotherapy: a systematic review of barriers, enablers and interventions *Physiotherapy* 100:208-219 doi:10.1016/j.physio.2014.03.001
- [13] Upton D, Stephens D, Williams B et al. (2014) Occupational therapists' attitudes, knowledge, and implementation of evidence-based practice: a systematic review of published research *British Journal of Occupational Therapy* 77:24-38 doi:<https://doi.org/10.4276/030802214X13887685335544>
- [14] Jeffery H, Robertson L, Reay KL (2020) Sources of evidence for professional decision-making in novice occupational therapy practitioners: clinicians' perspectives *British Journal of Occupational Therapy*:0308022620941390 doi:10.1177/0308022620941390
- [15] Robertson L, Graham F, Anderson J (2013) What actually informs practice: occupational therapists' views of evidence *British Journal of Occupational Therapy* 76:317-324 doi:<https://doi.org/10.4276/030802213X13729279114979>
- [16] Hamaideh SH (2016) Sources of Knowledge and Barriers of Implementing Evidence-Based Practice Among Mental Health Nurses in Saudi Arabia *Perspectives in psychiatric care* 53:190-198 doi:10.1111/ppc.12156
- [17] Shepherd D, Csako R, Landon J et al. (2018) Documenting and Understanding Parent's Intervention Choices for Their Child with Autism Spectrum Disorder *J Autism Dev Disord* 48:988-1001 doi:10.1007/s10803-017-3395-7
- [18] Mathes T, Buehn S, Prengel P et al. (2018) Registry-based randomized controlled trials merged the strength of randomized controlled trials and observational studies and give rise to more pragmatic trials *Journal of Clinical Epidemiology* 93:120-127 doi:<https://doi.org/10.1016/j.jclinepi.2017.09.017>
- [19] National Library of Medicine ClinicalTrials.gov Background. <https://clinicaltrials.gov/ct2/about-site/background>. Accessed January 29 2021
- [20] Wilson GT (1996) Manual-based treatments: the clinical application of research findings *Behav Res Ther* 34:295-314 doi:10.1016/0005-7967(95)00084-4
- [21] Holmqvist R, Philips B, Barkham M (2015) Developing practice-based evidence: Benefits, challenges, and tensions *Psychotherapy Research* 25:20-31 doi:<https://doi.org/10.1080/10503307.2013.861093>
- [22] Abry T, Hulleman CS, Rimm-Kaufman SE (2015) Using indices of fidelity to intervention core components to identify program active ingredients *American Journal of Evaluation* 36:320-338 doi:10.1177/1098214014557009
- [23] Glasgow RE, Eckstein ET, ElZarrad MK (2013) Implementation Science Perspectives and Opportunities for HIV/AIDS Research: Integrating Science, Practice, and Policy *JAIDS Journal of Acquired Immune Deficiency Syndromes* 63:S26-S31 doi:10.1097/QAI.0b013e3182920286
- [24] Khalil H (2016) Knowledge translation and implementation science: what is the difference? *JBI Evidence Implementation* 14:39-40 doi:10.1097/xeb.0000000000000086

- [25] Aarons GA, Ehrhart MG, Farahnak LR et al. (2014) Aligning Leadership Across Systems and Organizations to Develop a Strategic Climate for Evidence-Based Practice Implementation *Annual Review of Public Health* 35:255-274 doi:10.1146/annurev-publhealth-032013-182447
- [26] Yadav BL, Fealy GM (2012) Irish psychiatric nurses' self-reported sources of knowledge for practice *J Psychiatr Ment Health Nurs* 19:40-46 doi:10.1111/j.1365-2850.2011.01751.x
- [27] Ahn AC, Tewari M, Poon C-S et al. (2006) The limits of reductionism in medicine: could systems biology offer an alternative? *PLoS Med* 3:e208
- [28] Grocott MP (2013) *Integrative physiology and systems biology: reductionism, emergence and causality*. Springer,
- [29] American Physical Therapy Association (2011) *Vision 2020* Available at: http://www.apta.org/AM/Template.cfm?Section=Vision_2020&Template=/TaggedPage/TaggedPageDisplay.cfm&TPLID=285&ContentID=32061 Accessed January 3, 2013
- [30] Wolkenhauer O, Green S (2013) The search for organizing principles as a cure against reductionism in systems medicine *The FEBS journal* 280:5938-5948 doi:<https://doi.org/10.1111/febs.12311>
- [31] Zorek J, Raehl C (2013) Interprofessional education accreditation standards in the USA: a comparative analysis *J Interprof Care* 27:123-130 doi:10.3109/13561820.2012.718295
- [32] McDougall A, Goldszmidt M, Kinsella EA et al. (2016) Collaboration and entanglement: An actor-network theory analysis of team-based intraprofessional care for patients with advanced heart failure *Soc Sci Med* 164:108-117 doi:10.1016/j.socscimed.2016.07.010
- [33] Gambrill E (2012) *Critical Thinking in Clinical Practice*. John Wiley & Sons., Hoboken, New Jersey
- [34] Fava L, Morton J (2009) Causal modeling of panic disorder theories *Clin Psychol Rev* 29:623-637 doi:10.1016/j.cpr.2009.08.002
- [35] Pilecki B, Arentoft A, McKay D (2011) An evidence-based causal model of panic disorder *J Anxiety Disord* 25:381-388 doi:10.1016/j.janxdis.2010.10.013
- [36] Scaffa ME, Wooster DM (2004) Effects of problem-based learning on clinical reasoning in occupational therapy *Am J Occup Ther* 58:333-336 doi:10.5014/ajot.58.3.333
- [37] Masek A, Yamin S (2011) Problem based learning for epistemological competence: The knowledge acquisition perspectives *Journal of Technical Education and Training* 3 doi:<https://publisher.uthm.edu.my/ojs/index.php/ITET/article/view/257>
- [38] Schmidt HG, Rikers RM (2007) How expertise develops in medicine: knowledge encapsulation and illness script formation *Medical education* 41:1133-1139 doi:<https://doi.org/10.1111/j.1365-2923.2007.02915.x>
- [39] Facione NC, Facione PA (2008) *Critical thinking and clinical judgment. Critical thinking and clinical reasoning in the health sciences: A teaching anthology*.
- [40] Newell A (1990) *Unified theories of cognition* cambridge university press Cambridge, MA
- [41] Howard J (2014) Feeling Our Way with Intuition M a Rt I N Robson. In: Liebowitz J (ed) *Bursting the Big Data Bubble*. Auerbach, Boca Raton, Florida, pp 40-57. doi:10.1201/b17247-6
- [42] Bornstein BH, Emler AC (2001) Rationality in medical decision making: a review of the literature on doctors' decision-making biases *J Eval Clin Pract* 7:97-107 doi:10.1046/j.1365-2753.2001.00284.x
- [43] Mamede S, Schmidt HG, Rikers R (2007) Diagnostic errors and reflective practice in medicine *J Eval Clin Pract* 13:138-145 doi:10.1111/j.1365-2753.2006.00638.x
- [44] Klein JG (2005) Five pitfalls in decisions about diagnosis and prescribing *BMJ: British Medical Journal* 330:781 doi:<https://doi.org/10.1136/bmj.330.7494.781>
- [45] Schwartz A, Elstein AS (2008) *Clinical reasoning in medicine* In J Higgs, M Jones, S Loftus, & N Christensen (Eds) *Clinical reasoning in the health professions* 3rd ed Edinburgh: Elsevier:223-234
- [46] Mann K, Gordon J, MacLeod A (2009) Reflection and reflective practice in health professions education: a systematic review *Adv Health Sci Educ Theory Pract* 14:595-621 doi:10.1007/s10459-007-9090-2

- [47] Cross V (1993) Introducing physiotherapy students to the idea of 'reflective practice' *Medical Teacher* 15:293-307
- [48] Donaghy ME, Morss K (2000) Guided reflection: A framework to facilitate and assess reflective practice within the discipline of physiotherapy *Physiotherapy Theory and Practice* 16:3-14
- [49] Entwistle N, Ramsden P (1983) *Understanding learning* Croom Helm, London
- [50] Routledge J, Willson M, McArthur M et al. (1997) Reflection on the development of a reflective assessment *Medical teacher* 19:122-128
- [51] King G, Currie M, Bartlett DJ et al. (2007) The development of expertise in pediatric rehabilitation therapists: Changes in approach, self-knowledge, and use of enabling and customizing strategies *Developmental Neurorehabilitation* 10:223-240
- [52] Johns C (1994) Nuances of reflection *J Clin Nurs* 3:71-74 doi:10.1111/j.1365-2702.1994.tb00364.x
- [53] Koole S, Dornan T, Aper L et al. (2011) Factors confounding the assessment of reflection: a critical review *BMC Med Educ* 11:104 doi:10.1186/1472-6920-11-104
- [54] Larrivee B (2008) Development of a tool to assess teachers' level of reflective practice *Reflective Practice* 9:341-360 doi:10.1080/14623940802207451
- [55] Rassafiani M (2009) Is length of experience an appropriate criterion to identify level of expertise? *Scandinavian Journal of Occupational Therapy*:1-10 doi:<https://doi.org/10.3109/11038120902795441>
- [56] Wainwright S, Shepard K, Harman L et al. (2011) Factors that influence the clinical decision making of novice and experienced physical therapists *Physical Therapy* 91:87-101 doi:<https://doi.org/10.2522/ptj.20100161>
- [57] Benner P (1984) *From novice to expert* Menlo Park
- [58] Eva KW, Cunnington JP, Reiter HI et al. (2004) How can I know what I don't know? Poor self assessment in a well-defined domain *Advances in Health Sciences Education* 9:211-224 doi:<https://doi.org/10.1023/B:AHSE.0000038209.65714.d4>
- [59] Eva KW, Regehr G (2008) "I'll never play professional football" and other fallacies of self - assessment *Journal of Continuing Education in the Health Professions* 28:14-19 doi:<https://doi.org/10.1002/chp.150>
- [60] Galbraith RM, Hawkins RE, Holmboe ES (2008) Making self-assessment more effective *J Contin Educ Health Prof* 28:20-24 doi:10.1002/chp.151
- [61] Furnari S, Crilly D, Misangyi VF et al. (2020) Capturing causal complexity: Heuristics for configurational theorizing *Academy of Management Review* doi:<https://doi.org/10.5465/amr.2019.0298>
- [62] Gopnik A, Glymour C, Sobel DM et al. (2004) A theory of causal learning in children: causal maps and Bayes nets *Psychol Rev* 111:3-32 doi:10.1037/0033-295X.111.1.3
- [63] Hattori M, Oaksford M (2007) Adaptive non-interventional heuristics for covariation detection in causal induction: model comparison and rational analysis *Cogn Sci* 31:765-814 doi:10.1080/03640210701530755
- [64] Friston K, Schwartenbeck P, FitzGerald T et al. (2014) The anatomy of choice: dopamine and decision-making *Philos Trans R Soc Lond B Biol Sci* 369:20130481 doi:10.1098/rstb.2013.0481
- [65] Lu H, Yuille AL, Liljeholm M et al. (2008) Bayesian generic priors for causal learning *Psychol Rev* 115:955-984 doi:10.1037/a0013256
- [66] Sloman S (2005) *Causal models: How people think about the world and its alternatives*. Oxford University Press,
- [67] Waldmann MR, Hagmayer Y (2013) *Causal reasoning*
- [68] Rehder B, Kim S (2006) How causal knowledge affects classification: A generative theory of categorization *J Exp Psychol Learn Mem Cogn* 32:659-683 doi:10.1037/0278-7393.32.4.659
- [69] Davies M (2011) Concept mapping, mind mapping and argument mapping: what are the differences and do they matter? *Higher education* 62:279-301 doi: 10.1007/s10734-010-9387-6
- [70] Daley BJ, Torre DM (2010) Concept maps in medical education: an analytical literature review *Med Educ* 44:440-448 doi:10.1111/j.1365-2923.2010.03628.x
- [71] McHugh Schuster P (2016) *Concept Mapping a Critical-Thinking Approach to Care Planning*. F.A.Davis, Philadelphia, PA

- [72] Blackstone S, Iwelunmor J, Plange-Rhule J et al. (2017) Sustaining Nurse-Led Task-Shifting Strategies for Hypertension Control: A Concept Mapping Study to Inform Evidence-Based Practice Worldviews Evid Based Nurs 14:350-357 doi:10.1111/wvn.12230
- [73] Powell BJ, Beidas RS, Lewis CC et al. (2017) Methods to Improve the Selection and Tailoring of Implementation Strategies J Behav Health Serv Res 44:177-194 doi:10.1007/s11414-015-9475-6
- [74] Mehlman MJ (2005) Quackery Am J Law Med 31:349-363 doi:10.1177/009885880503100209
- [75] Ruitter RA, Crutzen R (2020) Core processes: how to use evidence, theories, and research in planning behavior change interventions Frontiers in Public Health 8:247 doi:<https://doi.org/10.3389/fpubh.2020.00247>
- [76] Bannigan K, Moores A (2009) A model of professional thinking: integrating reflective practice and evidence based practice Canadian Journal of Occupational Therapy 76:342-350 doi:<https://doi.org/10.1177/000841740907600505>
- [77] Krueger RB, Sweetman MM, Martin M et al. (2020) Occupational Therapists' Implementation of Evidence-Based Practice: A Cross Sectional Survey Occup Ther Health Care 34:253-276 doi:10.1080/07380577.2020.1756554
- [78] Cole JR, Persichitte KA (2000) Fuzzy cognitive mapping: Applications in education International Journal of Intelligent Systems 15:1-25 doi:[https://doi.org/10.1002/\(SICI\)1098-111X\(200001\)15:1<1::AID-INT1>3.0.CO;2-V](https://doi.org/10.1002/(SICI)1098-111X(200001)15:1<1::AID-INT1>3.0.CO;2-V)
- [79] Harden RM (1999) What is a spiral curriculum? Medical teacher 21:141-143 doi:<https://doi.org/10.1080/01421599979752>
- [80] Clark AM (2013) What are the components of complex interventions in healthcare? Theorizing approaches to parts, powers and the whole intervention Soc Sci Med 93:185-193 doi:10.1016/j.socscimed.2012.03.035
- [81] Whyte J, Dijkers MP, Hart T et al. (2014) Development of a theory-driven rehabilitation treatment taxonomy: conceptual issues Arch Phys Med Rehabil 95:S24-32 e22 doi:10.1016/j.apmr.2013.05.034
- [82] Levack WM, Meyer T, Negrini S et al. (2017) Cochrane Rehabilitation Methodology Committee: an international survey of priorities for future work Eur J Phys Rehabil Med 53:814-817 doi:10.23736/S1973-9087.17.04958-9
- [83] Hart T, Ehde DM (2015) Defining the treatment targets and active ingredients of rehabilitation: Implications for rehabilitation psychology Rehabil Psychol 60:126-135 doi:10.1037/rep0000031
- [84] Dombrowski SU, O'Carroll RE, Williams B (2016) Form of delivery as a key 'active ingredient' in behaviour change interventions British Journal of Health Psychology 21:733-740 doi:<https://doi.org/10.1111/bjhp.12203>
- [85] Wolf SL, Winstein CJ, Miller JP et al. (2006) Effect of Constraint-Induced Movement Therapy on Upper Extremity Function 3 to 9 Months After Stroke The EXCITE Randomized Clinical Trial JAMA 296:2095-2104 doi:10.1001/jama.296.17.2095
- [86] Hoare BJ, Wallen MA, Thorley MN et al. (2019) Constraint-induced movement therapy in children with unilateral cerebral palsy Cochrane Database Syst Rev 4:CD004149 doi:10.1002/14651858.CD004149.pub3
- [87] Gordon AM, Hung YC, Brandao M et al. (2011) Bimanual training and constraint-induced movement therapy in children with hemiplegic cerebral palsy: a randomized trial Neurorehabil Neural Repair 25:692-702 doi:10.1177/1545968311402508
- [88] Waddell KJ, Strube MJ, Bailey RR et al. (2017) Does task-specific training improve upper limb performance in daily life poststroke? Neurorehabilitation and neural repair 31:290-300 doi:<https://doi.org/10.1177/1545968316680493>
- [89] Lang CE, Lohse KR, Birkenmeier RL (2015) Dose and timing in neurorehabilitation: prescribing motor therapy after stroke Curr Opin Neurol 28:549-555 doi:10.1097/WCO.0000000000000256
- [90] Jette AM (2020) Opening the Black Box of Rehabilitation Interventions Physical Therapy 100:883-884 doi:10.1093/ptj/pzaa078
- [91] Lenker JA, Fuhrer MJ, Jutai JW et al. (2010) Treatment theory, intervention specification, and treatment fidelity in assistive technology outcomes research Assist Technol 22:129-138; quiz 139-140 doi:10.1080/10400430903519910
- [92] Johnston MV, Dijkers MP (2012) Toward improved evidence standards and methods for rehabilitation: recommendations and challenges Arch Phys Med Rehabil 93:S185-199 doi:10.1016/j.apmr.2011.12.011
- [93] Sinha Y, Silove N, Hayen A et al. (2011) Auditory integration training and other sound therapies for autism spectrum disorders (ASD) Cochrane Database Syst Rev:CD003681 doi:10.1002/14651858.CD003681.pub3
- [94] Bérard G (1993) Hearing equals behavior. Keats Publishing, New Canaan, CT

- [95] American Speech-Language-Hearing Association (2004) Auditory integration training[Technical Report]. American Speech-Language-Hearing Association. Accessed January 22 2021