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Interventions for undergraduate and postgraduate medical learners with academic difficulties: A BEME systematic review update: BEME Guide No. 85

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ABSTRACT

Background: Clinical teachers often struggle to record trainee underperformance due to lacking evidence-based remediation options.

Objectives: To provide updated evidence-based recommendations for addressing academic difficulties among undergraduate and postgraduate medical learners.

Methods: A systematic review searched databases including MEDLINE, CINAHL, EMBASE, ERIC, Education Source, and PsycINFO (2016–2021), replicating the original Best Evidence Medical Education 56 review strategy. Original research/innovation reports describing intervention(s) for medical learners with academic difficulties were included. Data extraction used Michie's Behaviour Change Techniques (BCT) Taxonomy and program evaluation models from Stufflebeam and Kirkpatrick. Quality appraised used the Mixed Methods Appraisal Tool (MMAT). Authors synthesized extracted evidence by adapting GRADE approach to formulate recommendations.

Results: Eighteen articles met the inclusion criteria, primarily addressing knowledge (66.7%), skills (66.7%), attitudinal problems (50%) and learner's personal challenges (27.8%). *Feedback and monitoring* was the most frequently employed BCT. Study quality varied (MMAT 0–100%). We identified nineteen interventions (UG: $n=9$, PG: $n=12$), introducing twelve new thematic content. Newly thematic content addressed contemporary learning challenges such as academic procrastination, and use of technology-enhanced learning resources. Combined with previous interventions, the review offers a total dataset of 121 interventions.

Conclusion: This review offers additional evidence-based interventions for learners with academic difficulties, supporting teaching, learning, faculty development, and research efforts.

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remediation

Introduction

Addressing underperformance among medical learners is a crucial aspect of medical education, as a significant proportion (10%–15%) of learners encounter difficulties during their training (Shearer et al. 2019; To et al. 2021). Although many initiatives are aimed at improving faculty members' teaching skills (Steinert et al. 2016) and summarizing remediation interventions in medical education (Guerrasio 2013; Chou and Kalet 2014; Chou et al. 2019), there is a lack of resources listing evidence-based interventions. Therefore, it is imperative to provide the best available evidence in medical education to effectively manage trainees' underperformance and prepare future generations of physicians to work effectively within complex healthcare systems. (Kalet et al. 2016; 2017).

In response to this need, a BEME (Best Evidence in Medical Education) review was conducted in 2016 to compile a range of literature-based interventions for undergraduate and postgraduate medical learners experiencing academic difficulties (Lacasse et al. 2019). The systematic

Practice points

- The 2019 BEME established a conceptual framework for academic difficulties. Gaining insight from the conceptual framework dimensions contributes to formulating educational diagnoses and remediation interventions.
- This 5-year updated BEME systematic review introduced twelve new thematic content addressing contemporary learning challenges such as academic procrastination and the use of technology-enhanced learning resources, and complemented seven existing thematic content from 2019, enhancing robustness in both tutoring and remediation plans.
- The overall dataset includes 121 interventions providing evidence-based interventions from 1990 to 2021. These interventions addressed educational diagnoses related to knowledge deficits, unsatisfactory skills, attitudinal concerns, learners' personal issues, and challenges at both teacher and environment levels.

review synthesized articles published from 1990 to 2016 and provided valuable outcomes, including effective interventions that could support medical learners facing

difficulties. The review also classified interventions using the Behaviour Change Techniques (BCTs) framework in an attempt to enhance clinical teachers' and educators' understanding of the theoretical foundations behind each intervention and promote their implementation.

Since the publication of the previous BEME review, new studies focusing on medical remediation have emerged. Shearer et al. (2019) conducted a literature review to identify best practices in remediation by reviewing remediation policies from 13 English-speaking medical schools in Canada. They found that while most policies aligned well with some published best practices (Chou and Kalet 2014), most proposed interventions were expert recommendations lacking support from published studies. To et al. (2021) conducted a narrative analysis on remediation of trainees in medical and surgical sub-specialties to provide recommendations for underperforming surgical trainees. They reviewed 55 articles, half of which were specific to surgical trainees, and they were able to identify system- and process-level recommendations. They concluded that despite the complexity of programmatic remediation approaches, they often yielded positive outcomes. They also recommended future development of collaborative protocols to synergize efforts in the field of medical remediation. Yan et al. (2022) performed a PRISMA-based literature review to identify current remediation practices, define successful remediation strategies, and determine their effectiveness. Their review revealed that trainees experiencing difficulties were less likely to be board certified, but attrition rates did not differ significantly. However, because of limited and conflicting data, they couldn't evaluate the effectiveness of specific remediation strategies or determine superior ones.

By reconducting the search methodology of BEME 56, this 5-year update aims to identify new remediation strategies for undergraduate and postgraduate medical students and establish the strength of recommendation regarding their use. Specifically, this review seeks to answer the following research questions:

- What types of interventions (e.g. workshops; longitudinal programs) have been provided in the field of medical remediation in the past five years?
- Are there interventions addressing new themes (e.g. environmental interventions, faculty development and technology)?
- Are there recent studies supporting the interventions already identified in the original BEME review and subsequently modifying the strength of recommendation for their use?

Conceptual frameworks

Medical education literature extensively discusses factors that influence academic difficulties during undergraduate or postgraduate medical training, as well as educational diagnoses (Cariaga-Lo et al. 1997; Stern et al. 2005; Yates and James 2006). Various frameworks have been proposed to analyse challenging learning situations in medical education (Shapiro et al. 1987; Gordon 1993; Vaughn et al. 1998; Kahn 2001; Mitchell et al. 2005). One widely recognised framework, proposed by Steinert (2008, 2013) and adapted

as the Educational Diagnosis Wheel (Lacasse 2009), encompasses and summarizes many of these frameworks. This conceptual framework adopts a socio-constructivist approach to learning, emphasizing the interactive relationship between the learner and the teacher within a learning environment or system. The online platform, MedEd DxTx, which provides remediation interventions for medical learners facing difficulties, relies on the Educational Diagnosis Wheel framework, as depicted in Figure 1.

From a theoretical perspective, most studies describing interventions for learners experiencing academic difficulties do not explicitly provide a conceptual framework (Cleland et al. 2013). However, since much of health professional practices can be viewed as forms of behaviour, educational interventions should leverage behavioral change theories and strategies in their design. A reliable method has been developed to specify groups of BCTs, outlined in Supplemental Table 1, which aids in identifying intervention content and their proposed mechanisms of change (Michie et al. 2015). The original version of BEME 56 utilized this taxonomy to classify interventions during the process of data extraction and analysis (Lacasse et al. 2019). By categorizing interventions into 16 groupings associated with educational diagnoses, this taxonomy enhanced the understanding of educational interventions and their alignment with specific goals.

Objectives

The objective of this review is to provide an update on the prior BEME 56 review (Lacasse et al. 2019) by identifying interventions targeting undergraduate (UG) and postgraduate (PG) medical learners experiencing academic difficulties within the last five years. Our exploration involves investigating the presence of interventions addressing new themes and assessing whether recent studies lend support to the previously identified interventions in the original BEME review. This assessment has the potential to influence the strength of recommendations for their use.

Methods

This systematic review adhered to the BEME systematic review framework. The review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines (Moher et al. 2009) (Appendix 1). Approval to perform this updated review was obtained from BEME Collaboration in November 2021, and the Review team followed established BEME review procedures.

Search sources and strategies

Multiple databases were systematically searched, including MEDLINE, CINAHL, EMBASE, ERIC, Education Source and PsycINFO. The search strategy combined the following concepts: (1) medical education, (2) professional competence or difficulty, and (3) educational support. A detailed presentation of the keywords used and search strategy can be found in Supplementary Appendix 2. The literature search covered the period from December 20, 2016, to December

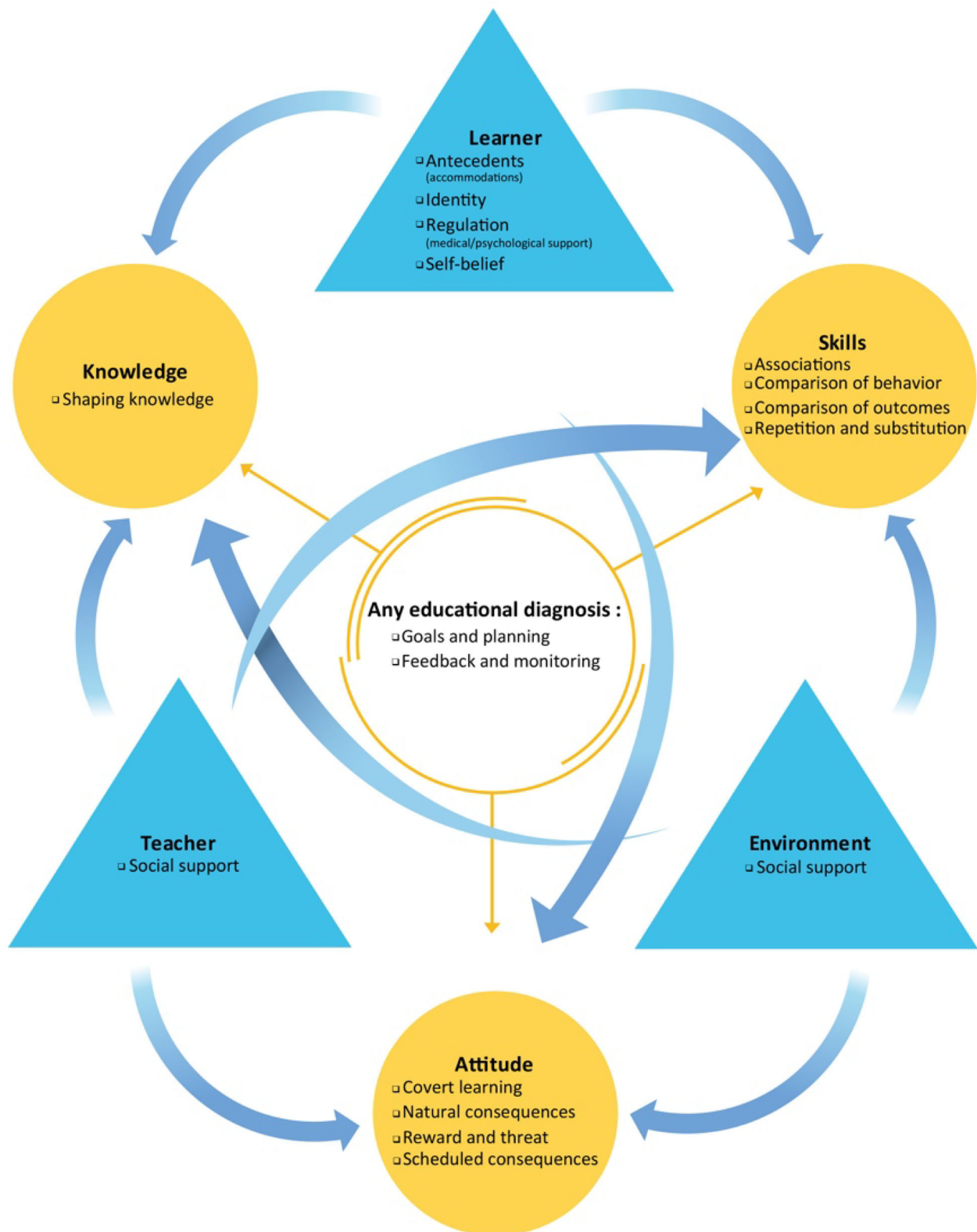


Figure 1. Educational diagnosis wheel and distribution of behavior Change techniques grouping. This figure represents the educational diagnosis wheel which is adapted from Lacasse (2009) and embodies a socio-constructivist approach to learning. Within this framework, the *learner* engages in interactive exchanges with a *teacher* within a learning *environment* or system. The education diagnosis wheel encompasses various dimensions of *learner* issues, including academic difficulties pertaining to fundamental, clinical, procedural or work setting *knowledge*; cognitive, interpersonal, structural or procedural *skills*; and personal, interpersonal or professional *attitudes*. Additionally, personal life issues such as health, spouse/family matters, financial concerns, cultural adaptation, and social life intersect with challenges at the *teacher* level, such as personal life issues or deficiencies in faculty development, as well as *environment/system level* factors like learning climate or learning conditions. These interconnected factors, as depicted by the blue arrows, often impact the development of competencies and subsequent academic success. However, it is important to note that while these underlying problems may contribute to the educational diagnosis, they should not serve as excuses for competence issues. Instead, they should be used to elucidate the educational diagnosis and inform the development of appropriate remediation strategies. The figure also highlights the BCTs grouping in proximity to the educational diagnosis with which they are predominantly associated.

31, 2021. Articles written in languages other than English or French were excluded.

Study selection criteria

The reviewers used the online software Covidence (<https://www.covidence.org>) to screen titles, abstracts, full-text articles, and to extract data. Inclusion criteria for article selection were:

- Description of an original research study or innovation report;
- Medical discipline;
- Focus on undergraduate students or postgraduate trainees experiencing academic difficulties;
- Description of at least one intervention strategy aimed at supporting learners with academic difficulties;
- Inclusion of at least one form of program evaluation.

We excluded articles that were purely descriptive without an evaluative methodology, lacked a description of an intervention, or targeted learners who were not experiencing academic difficulties. Additionally, we excluded articles aimed at other healthcare training programs or written in languages other than English and French. After removing duplicates, one reviewer (JM) screened all titles and abstracts identified by the search strategy and excluded reports that did not meet inclusion criteria. In situations where relevance was uncertain, articles were not eliminated at this stage and were assessed by another independent reviewer (ML). Two reviewers (JM and ML) independently assessed the remaining full-text articles by using the inclusion and exclusion criteria. Full-text articles were retrieved for all potentially relevant citations, and the bibliographies of selected articles were also searched to ensure the inclusion of key studies. A third reviewer (AL) was consulted if discrepancies arose in the process.

Data extraction

For each article, the reviewers extracted data related to each intervention strategy, including the targeted educational diagnoses and BCTs grouping. We also extracted program evaluation design data, including the effectiveness of outcomes and quality appraisal. Two random pairs of reviewers independently extracted data from all full-text articles selected on the data extraction template ([Supplementary Appendix 3](#)). In cases of discrepancies, a final decision was reached by a pair of reviewers (JM and ML).

Behaviour change techniques grouping

Data extraction regarding each intervention strategy followed Michie's BCTs Taxonomy (Michie et al. 2015), using the same classification as the original review. The reviewers extracted up to three BCTs for each intervention strategy retrieved from each article ([Supplemental Table 1](#)).

Program evaluation and importance of outcomes

The program evaluation models developed by Stufflebeam and Kirkpatrick were used in the original review. The modified version of Kirkpatrick's classification of training

outcomes proposed by Issenberg et al. (2005) and (Freeth et al. 2005), and adopted by the BEME collaboration as a grading standard for systematic reviews (Hammick et al. 2010), was used to classify the outcomes during the extraction of program evaluation data. This classification does not assume any causality or hierarchy between the different levels, which include:

- Level 1: Reaction;
- Level 2A: Change of attitudes;
- Level 2B: Change of knowledge and/or skills;
- Level 3: Behavioral change (self-reported/observed, as suggested by Steinert et al. (2012));
- Level 4A: Changes in professional practice;
- Level 4B: Benefits to patients.

Data were also extracted by reviewers using Stufflebeam (2003)'s CIPP model (context/input/process/product), which considers program evaluation beyond the scope of outcomes assessment. This model is a decision-focused approach to evaluation, providing systemic information for program managers (Fitzpatrick et al. 2011). The CIPP model examines the following aspects: Context refers to needs assessments, Input involves costs and feasibility, Process examines how the implementation unfolded, and Products describe the outcomes, presented here according to Kirkpatrick's classification levels.

Quality appraisal of studies

The quality of each included study was assessed by reviewers using the Mixed Methods Appraisal Tool (MMAT) (Pluye et al. 2011). This tool was chosen as it is specifically designed for concomitantly appraising and/or describing studies included in systematic mixed studies reviews. Reviews included original qualitative, quantitative and mixed methods studies.

The MMAT initially screens methodological quality with two questions and then asks design-specific questions (4 for qualitative or quantitative studies and 3 for mixed methods studies). A score out of 100% was then calculated, corresponding to the number of criteria met (25% for each criterion) for qualitative and quantitative studies, or to the quality of the weakest component in mixed methods studies. To assess the quality of a Delphi design, a systematic review recommending methodologic criteria for reporting Delphi studies from Diamond et al. (2014) was utilized.

Effectiveness of outcomes

To summarize the effectiveness of outcomes in each article as stated by the authors, two coders (JM, ML) analyzed the previously identified outcomes (by independent article reviewers) on a 3-point scale: harmful/not reported (0), inconclusive (1), slightly effective (e.g. statistically significant, but not educationally significant) (2) or effective (3). Consensus was established between the two coders for the final score.

Synthesis of extracted evidence

The lead reviewer conducted a thematic content analysis of all 18 articles to group all similar intervention strategies

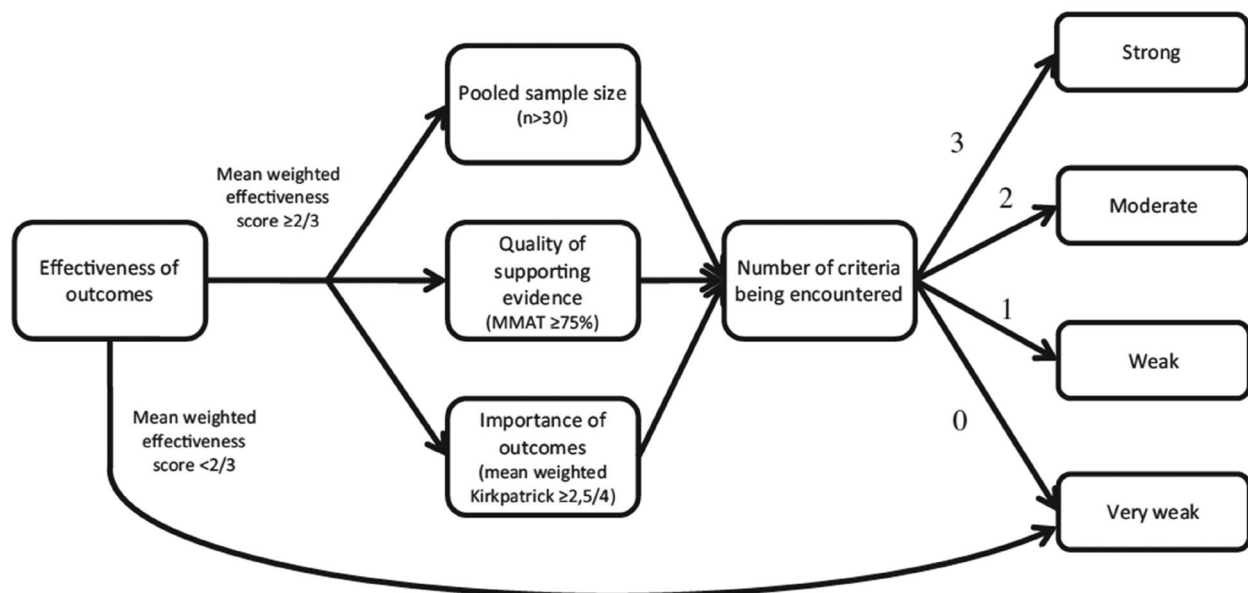


Figure 2. GRADE-like approach for determining the strength of recommendations.

The strength of recommendations was determined using a logical sequence based on the following criteria, adapted from the GRADE framework (www.gradeworkinggroup.org), for each intervention type:

Effectiveness of the outcomes or risk/benefit ratio: The evidence from each article was coded by assigning a score between 0 and 3 (0: harmful/not reported", 1: inconclusive, 2: slightly effective, 3: effective). A mean score was then computed for each intervention type by weighting each study according to its sample size. The criterion was considered "sufficient" if the weighted mean effectiveness score was equal to or greater than 2.

Pooled sample size: The total number of participants across studies was pooled, and the criterion was considered "sufficient" if the sum was equal to or greater than 30. This cut-off represents the commonly used, although arbitrary, minimum sample size for data to follow a normal distribution (Pett 2015).

Quality of supporting evidence: The quality of evidence was assessed using the MMAT for each article. A mean score was calculated for each intervention type, by weighting each study based on its sample size. The criterion was considered "sufficient" if the weighted mean MMAT score was equal to or greater than 75%.

Relative importance of outcomes: For each article, a score was assigned to reflect the relevance of the reported outcomes based on Kirkpatrick's levels (Kirkpatrick 1994). This score, ranging from 1 to 4, was then computed as a weighted mean, considering each article's sample size. The criterion was considered "sufficient" when the weighted mean score was equal to or greater than 2.5, indicating a greater emphasis on studies assessing levels 3 and 4.

into broader types of interventions. The codification was conservative, to avoid loss of data while facilitating synthesis and the formulation of recommendations. At the end of the data extraction process, the lead reviewer identified the main BCT for each type of intervention based on the data extracted by each pair of reviewers. Each type of intervention was then mapped to the relevant educational diagnoses, including knowledge, skills, attitudes, learner, teacher, and environment.

To establish the strength of recommendation for each intervention type, we employed an approach inspired by the GRADE guidelines (www.gradeworkinggroup.org). Four recommendation levels were considered: strong, moderate, weak and very weak. The strength of recommendation was determined following the approach described in Figure 2.

Results

Description of the articles

In this review, a total of 7,393 titles published between December 2016 and December 2021 were screened. Among them, 18 articles met the inclusion criteria (Figure 3) and were combined with the 68 articles from the previous review for a total of 86 studies published from 1990 to 2021. Of these new studies, 8 involved undergraduate (UG) learners, 9 involved postgraduate (PG) learners, and 1 article included both UG and PG and was therefore included in both groups for sub-analyses.

This update of 18 articles involved a total of 3,224 learners. The most common educational diagnoses observed among the learners were knowledge deficits (67%, UG: $n=4$, PG: $n=8$), unsatisfactory skills (67%, UG: $n=4$, PG:

$n=8$), attitudinal concerns (50%, UG: $n=7$, PG: $n=8$) and learner personal issues (28%, UG: $n=1$, PG: $n=4$). Addressing teacher issues (6%) or environmental/systems issues (6%) was less frequently reported. Supplemental Tables 3 and 4 demonstrate how many articles reported each type of intervention with their main BCT, with the training level where they were implemented (undergraduate/postgraduate), and the educational diagnoses for which they are relevant.

Methodological quality of the new studies

The methodological quality of the new 18 studies varied. The assessment designs included six qualitative designs, eleven quantitative designs (3 non-randomized and 8 descriptive) and one Delphi design. The MMAT scores ranged from 0% to 100%. Detailed results for the MMAT scores can be found in Supplemental Table 2. Total MMAT scores were compared to assess inter-rater reliability. However, it was not possible to compute inter-rater reliability for each individual criterion due the variability in study designs across the included studies. Instead, an intra-class correlation (2,2) between coders was calculated, resulting in a value of 0.63 ($p=0.019$), which indicated moderate reliability according to the criteria set by Koo and Li (2016).

Out of the six qualitative designs, five met the criteria for further appraisal. These designs had clear research questions that could be addressed by the collected data (83.3% mean score, range 0–100%). Additionally, they had relevant sources and a well-defined process for analyzing data, while also considering the contextual factors and the potential influence of the researchers.

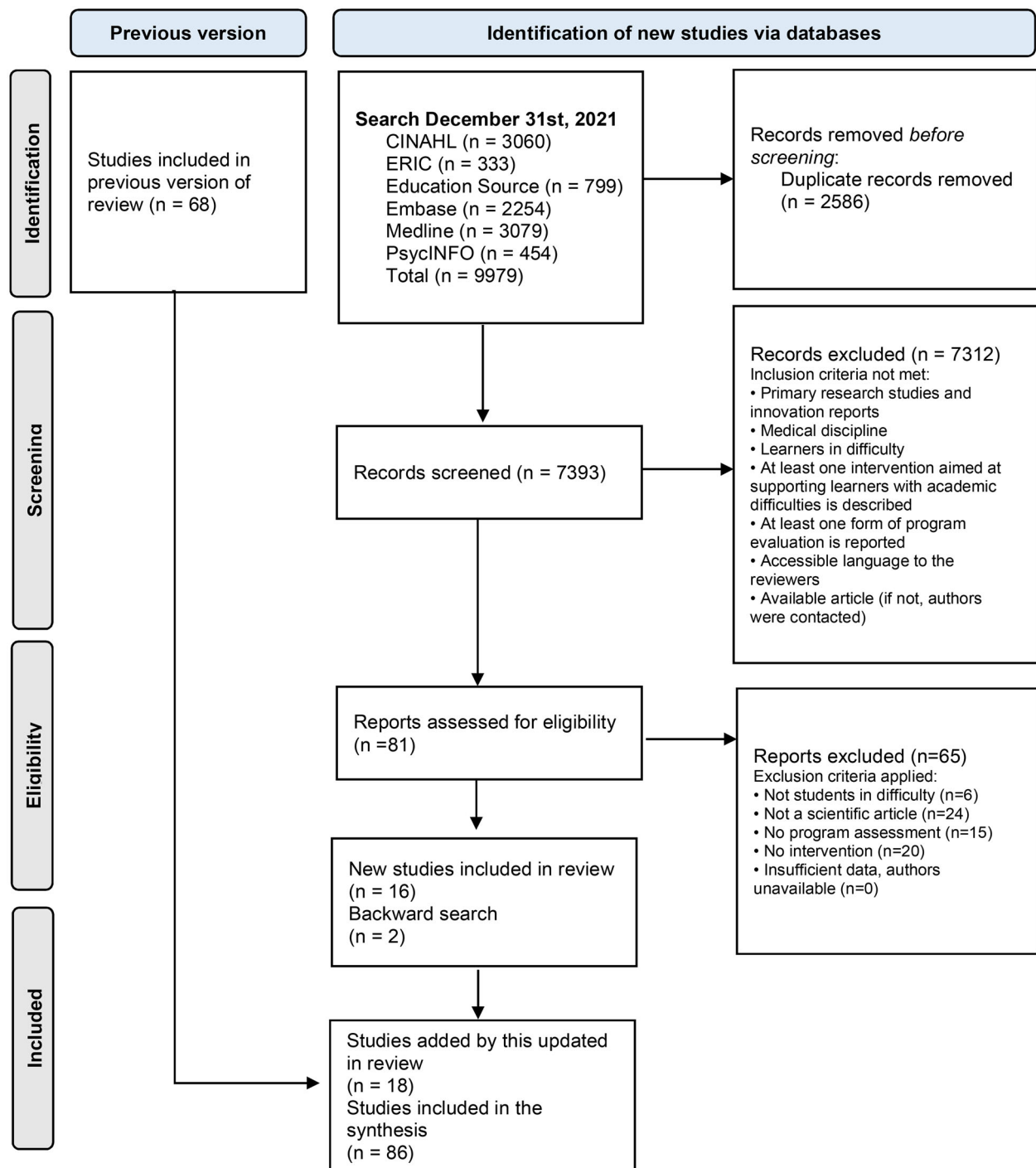


Figure 3. Flow chart.

Regarding the three quantitative non-randomized designs, two met the criteria necessary to calculate a score (41.7% mean score, range 0–100%). Those reports demonstrated efforts to minimize selection bias, appropriately measured the intervention, and achieved an acceptable response rate. However, they did not adequately consider differences between groups.

For the eight quantitative descriptive studies, all met the criteria for score calculation (93.8% mean score, range 0–100%). The studies employed a relevant sampling strategy, exhibited an acceptable response rate, and had a representative sample of the population under study. Furthermore, seven of the eight studies utilized an appropriate measurement strategy.

Lastly, the Delphi design met all criteria (100%) assessed for methodological quality.

Program evaluation and effectiveness of outcomes

Data extraction of program evaluation was conducted for all 18 articles using the four aspects of program evaluation, CIPP model (context/input/process/product), proposed by Stufflebeam (2003) (Figure 4). Among the studies that provided an assessment of context (44%), a majority presented data from needs assessments or described the goals underlying the development of the interventions.

Regarding the resources (Input) required for intervention development and implementation, only 22% of the articles reported on them. Several interventions involved the expertise of professionals, such as professionalism and communication experts (Warburton et al. 2017), experienced mentors in Mentoring Programs (Bellodi et al. 2021), academics with medical backgrounds (Findyartini and

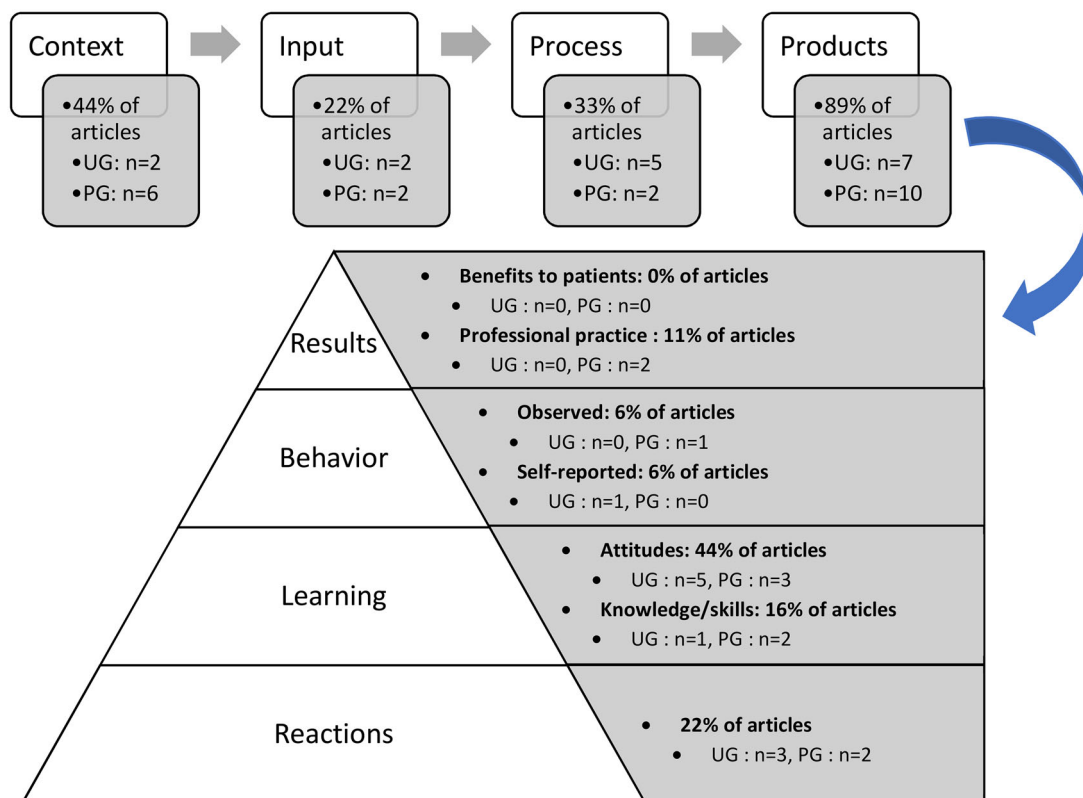


Figure 4. Distribution of the aspects of program evaluation (Stufflebeam 2003) among undergraduate and postgraduate of articles of this review. This figure specifically applies for the new 18 articles included in this BEME update.

Sudarsono 2018) and surgeons (Gas et al. 2016). The reported time required for remediation varied across studies. For example, it included three to four meetings with a single learner per year (Bellodi et al. 2021), a six-week remediation course including at least eight hours of observation of role models who were clinicians, researchers, and/or policy makers (Findyartini and Sudarsono 2018), five separated two-hour sessions (Gas et al. 2016), or a mean time commitment of up to 45 h per learner, including the time of faculty and administrative staff (Warburton et al. 2017). The costs incurred with the interventions were described in only one study, which were covered by the surgical program and surgical leadership (Gas et al. 2016). Notably, no funding from commercial sources was identified in this review.

Furthermore, 33% of the articles reported on their implementation process. These articles discussed how learners were referred to the remediation process (Warburton and Shahane 2020), the number of participants in their programs (Gray and Toms 2018), the characteristics of the participants (Moon et al. 2019), and the strategies that were employed (Boileau et al. 2019; Mak-van der Vossen et al. 2019; Moon et al. 2019; Bellodi et al. 2021). An article also provided suggestions by tutors for improving the academic tutoring program (Bellodi et al. 2021).

Regarding the outcomes, 89% of the articles reported on products or outcomes aligned with at least one of the four levels of Kirkpatrick's evaluation model (reactions, learning, behaviour and results).

In terms of the quality of supporting evidence and importance of outcomes, most articles reported effective (33%) or slightly effective (50%) outcomes, based on the conclusions drawn by the authors of each study. Only one article (6%) reported harmful data (Moniz et al. 2022). Two

articles (Mak-van der Vossen et al. 2019; Nadir et al. 2019) did not report any product or outcomes. The intra-class correlation (2,2) between the coders was calculated to be 0.97 ($p=0.000$), indicating excellent reliability (Koo and Li 2016).

Description of the new interventions

In this updated review, a total of eighteen studies were included, encompassing nineteen distinct interventions that were evaluated (UG: $n=9$, PG: $n=12$). Among these interventions, twelve identified new thematic content, while seven complemented the existing thematic content from 2019. The results, as shown in Table 1, highlight interventions with new thematic content, indicated in **bold**.

Out of the nineteen new interventions, seventeen (89%) had a weighted mean effectiveness score of $\geq 2/3$, twelve (63%) involved a pooled number of participants exceeding 30, and two (11%) had a weighted mean Kirkpatrick level outcomes of $\geq 2.5/4$.

Two interventions met criteria for "Strong" recommendation, nine were graded as "Moderate", six as "Weak" and two as "Very weak". The strengths of recommendations presented here resulted from pooling interventions for both undergraduate and postgraduate learners, and therefore may differ from Supplemental Tables 3 and 4.

Interventions with new thematic content

Among the nineteen interventions presented in this update, twelve of them introduced new thematic content. This section focuses on exploring the results of these interventions that incorporated new thematic content, aiming

Table 1. Summary of new interventions for learners experiencing academic difficulties ($n = 19$).

	Level			Educational diagnosis					Pooled number of participants (n)	Quality of evidence (weighted mean MMAT score (%))	Importance of results (weighted mean Kirkpatrick) (/4)	Magnitude of results (weighted mean effectiveness) (/3)	Strength of recommendation				
	Number of interventions	Undergraduate	Postgraduate	Knowledge	Skills	Attitude	Learner personal issues	Teacher environment						Learning environment			
Remediation interventions (references) under each behaviour change techniques grouping																	
Associations																	
Mobile application to verify and describe clinical reasoning difficulties (Boileau et al. 2019*)	1	1	1								●	0	100.0%	1.0	2.0	2.0	Weak
Comparison of behaviour Remediation course for professionalism lapse (Findyartini and Sudarsono 2018*)	1	1		●								14	100.0%	2.0	2.0	2.0	Weak
Feedback and monitoring Clinical skills assessment support on extension programme (Hawkrige and Molyneux 2019*)	1		1	●	●							67	75.0%	2.0	2.0	2.0	Moderate
Communication skills workshop (Anderson et al. 2017)	1		1	●	●	●	●				●	15	100.0%	2.0	2.0	2.0	Weak
Reflection (Guerrasio et al. 2014; Anderson et al. 2017)	2	1	2	●	●	●	●					161	69.7%	2.8	2.9	2.9	Moderate
Reflective writing to remediate professionalism (Moniz et al. 2022*)	1		1	●								0	100.0%	2.0	1.0	1.0	Very Weak
Goals and planning																	
Learning/remediation plan (Chur-Hansen 1999; Rowland et al. 2012; Katz et al. 2013; Guerrasio et al. 2014; Bierer et al. 2015*; Warburton et al. 2017*; Gray and Toms 2018*)	7	4	4	●	●	●	●					2592	87.6%	2.0	2.9	2.9	Strong
Three-phase approach for attending to professionalism lapses (Mak-van der Vossen et al. 2019*)	1	1		●								0	100.0%	0.0	0.0	0.0	Very Weak
Identity																	
Culture and transition workshop (Anderson et al. 2017)	1		1	●	●	●	●				●	15	100.0%	2.0	2.0	2.0	Weak
Regulation																	
Acceptance and commitment therapy on academic procrastination (Armani Kian et al. 2020*)	1	1		●								38	0.0%	3.0	3.0	3.0	Moderate
Psychological/psychiatric counseling/support (Walter and Croen, 1993; Segal et al., 1999; Powell, 2004; Reamy and Harman, 2006; Cleland et al., 2010; Brokaw et al. 2011; Mysorekar, 2012; Yaghoubian et al. 2012; Bhatti et al., 2016; Sparks et al. 2016; Warburton and Shahane 2020*)	11	6	5				●					1920	88.7%	1.2	2.9	2.9	Moderate

(continued)

Table 1. Continued.

	Level		Educational diagnosis					Pooled number of participants (n)	Quality of evidence (weighted mean MMAT score (%))	Importance of results (weighted mean Kirkpatrick) (/4)	Magnitude of results (weighted mean effectiveness) (/3)	Strength of recommendation
	Undergraduate	Postgraduate	Knowledge	Skills	Attitude	Learner personal issues	Teacher					
Remediation interventions (references) under each behaviour change techniques grouping												
Repetition and substitution												
Deliberate practice-based remediation program (Moon et al. 2019*)	1	1	●	●	●		620	75.0%	2.0	3.0	Moderate	
Simulation (Cleland et al. 2010; Guerrasio et al. 2014; Nadir et al. 2019*)	3	2	●	●	●		915	99.3%	1.0	3.0	Moderate	
Supervised practice (Pickell et al., 1991; Hardy, 1999; Sayer et al., 2002; Cleland et al. 2013; Audétat et al., 2011; Pell et al. 2012; Gas et al. 2016*)	7	2	●	●	●		1272	88.0%	1.2	2.7	Moderate	
Supplemental training - year (Kies and Freund 2005; Rehm and Rowland 2005*; Brokaw et al. 2011; Dupras et al. 2012; Pell et al. 2012; Yaghoubian et al. 2012; Homer et al. 2018*)	7	3	●	●	●		1140	88.0%	1.1	2.6	Moderate	
Shaping knowledge												
Structured weekly reading assignments and quiz (Wasicek et al. 2019*)	1	1	●	●			23	100.0%	2.0	3.0	Weak	
Social support												
Hybrid coaching model: deliberate practice and coregulated learning (Yonder and Pandey, 2021*)	1	1	●	●			103	50.0%	2.0	2.0	Weak	
Mentoring for test-taking skills (Decoteau et al. 2018*)	1	1	●	●	●	●	52	100.0%	2.0	3.0	Moderate	
Tutoring and academic assistance (Magarian and Campbell, 1992; Walter and Croen, 1993; Segal et al. 1999; Enriquez Vliapana et al., 2008; White et al., 2009; Cleland et al. 2013; Sikkana, 2010; Brokaw et al. 2011; Yaghoubian et al. 2012; Bhatti et al. 2016; Sparks et al., 2016; Bellodi et al. 2021*)	12	3	●	●	●	●	3120	94.3%	1.9	2.5	Strong	

This table specifically applies for the new 18 articles included in this BEME update. Studies identified by a * were focused on a single intervention (i.e. not combined with other interventions in the program evaluation design). Interventions in **bold** type addressed new thematic content.

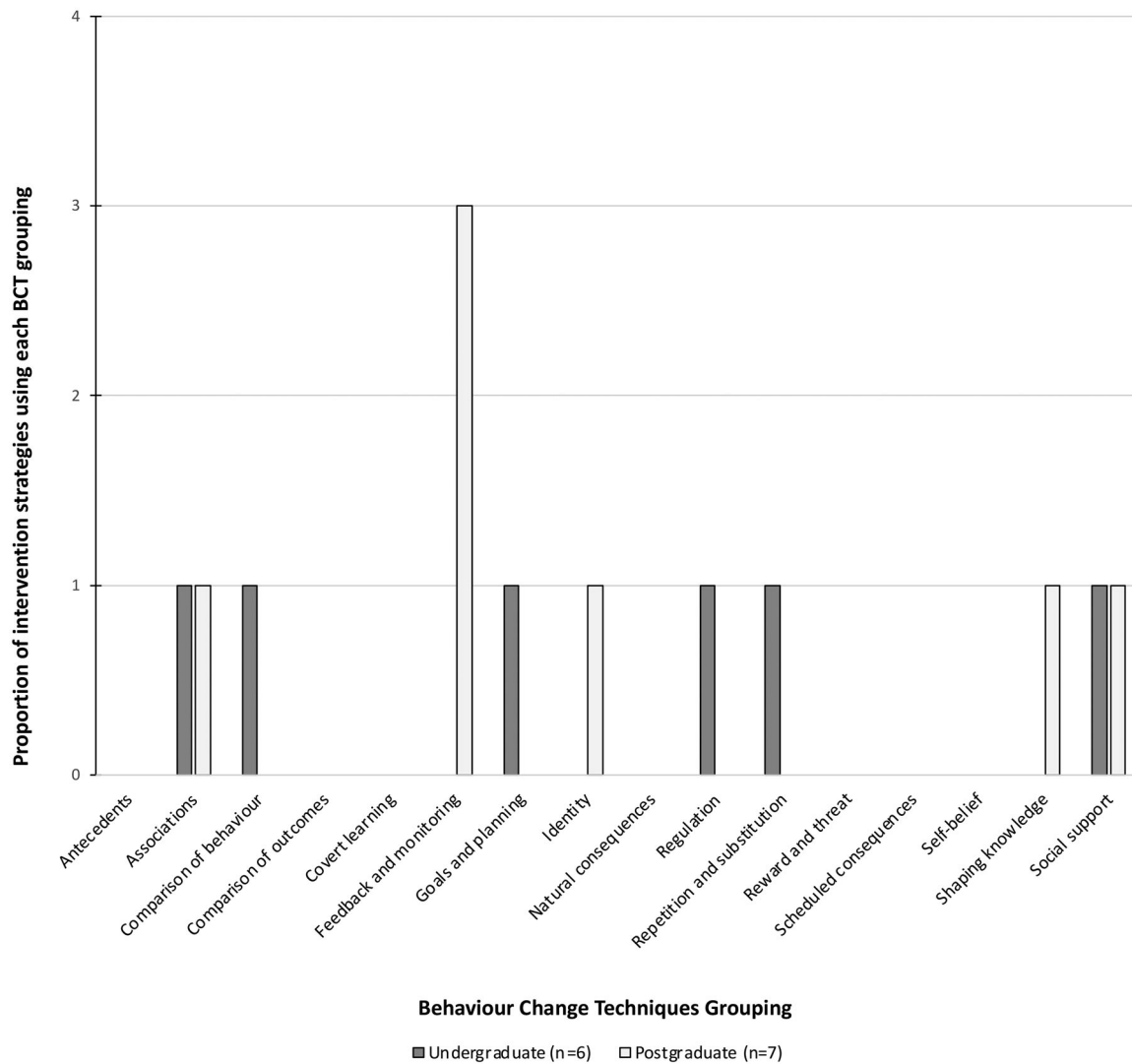


Figure 5. New intervention strategies using each behavior Change Techniques grouping in undergraduate and postgraduate learners ($n = 12$). This figure specifically pertains to the new thematic contents identified by the 18 articles included in this BEME update.

to provide a more comprehensive understanding of the novel aspects introduced by this updated BEME study.

The twelve interventions with new thematic content used nine different main BCTs. The distribution of interventions with new thematic content across each BCT grouping for undergraduate and postgraduate learners is depicted in Figure 5. Intra-class correlation (2,2) between coders was 0.93 ($p = 0.000$), indicating excellent reliability according to Koo and Li (2016).

Remediation contexts primarily utilized the Feedback and monitoring BCT (25%), with three distinct types of interventions designed for postgraduate trainees. An intervention involved providing *clinical skills assessment support on extension programme* for general practitioner trainees who have multiple fails in the clinical skills assessment ($n = 1$, Moderate), as studied by Hawkrigde and Molyneux (2019). A *communication skills workshop* was part of an enhanced induction programme for general practitioners' trainees identified at risk ($n = 1$, Weak), as described by Anderson et al. (2017). *Reflective writing to remediate professionalism* ($n = 1$, Very weak), aimed to facilitate attitude change by developing insight, but had uncertainty outcomes, with educators raising concerns about the sincerity, quality and effectiveness of reflective writing, as well as learner safety (Moniz et al. 2022).

Among the new strategies, one intervention introduced *a mobile application* that allowed teachers to assess and describe clinical reasoning difficulties among both undergraduate and postgraduate learners ($n = 1$, Weak) under the Associations BCT (Boileau et al. 2019).

Another new strategy, targeting undergraduate students, involved role-model shadowing and multi-source feedback throughout a *remediation course for professionalism lapse* ($n = 1$, Weak) under the Comparison of behaviour BCT (Findyartini and Sudarsono 2018).

A *three-phase approach for attending to professionalism lapses* ($n = 1$, Very Weak) was proposed to remediate attitudinal concerns for undergraduate students under the Goals and planning BCT (Mak-van der Vossen et al. 2019).

A *culture and transition workshop* ($n = 1$, Weak) for international medical graduates, under the Identity BCT, was facilitated by an international medical graduate general practitioner. It proposed discussions about cultural differences, personal experiences in the training process, and the transition to practice (Anderson et al. 2017).

Regulation BCT involved utilizing various pharmacological or nonpharmacological methods to reduce negative emotions and minimize mental demands, thereby facilitating behaviour change. A neuropsychological intervention, such as *Acceptance and Commitment Therapy on academic*

procrastination ($n=1$, Moderate) helped undergraduates with attitudinal difficulties (Armani Kian et al. 2020).

No intervention seemed to prompt Substitution of the unwanted behaviour with a wanted/neutral behaviour. However, many used Repetitions, in various contexts. Moon et al. (2019) studied a *deliberate practice-based remediation program* to remediate clinical and skills performance ($n=1$, Moderate).

Structured weekly reading assignments and quiz ($n=1$, weak) is a new thematic intervention of the Shaping knowledge BCT for residents scoring poorly on annual multiple-choice exam designed to measure their progress (Wasicek et al. 2019).

This updated review identified *hybrid coaching model: deliberate practice and coregulated learning* ($n=1$, weak) for undergraduates who had been unsuccessful on a previous clinic skills exam (Yonder and Pandey 2021). Additionally, *mentoring for test-taking skills* ($n=1$, Moderate) emerged as a new theme under the Social support BCT to address knowledge, skills, attitude concerns, and to provide support for postgraduates personal issues (Decoteau et al. 2018).

Interventions that complemented the thematic content from BEME 56

Among the nineteen interventions presented in this update, seven complemented the thematic content from 2019 BEME, as outlined in Table 1. To assess the overall strength of the recommendations, the pooled number of participants, the quality of evidence, the importance of results and magnitude of results data were combined with previous data using a weighted mean approach that considered the sample size of each intervention.

For example, results from Homer et al. (2018) were added to the intervention related to *supplemental year training*, which already encompassed results from Brokaw et al. (2011); Dupras et al. (2012); Kies and Freund (2005); Pell et al. (2012); Rehm and Rowland (2005); Yaghoubian et al. (2012). This consolidation raised the total of interventions to seven, while the level of recommendation remained moderate ($n=7$, Moderate).

The results from Warburton et al. (2017) and from Gray and Toms (2018) were added to the intervention related to *learning/remediation plan*, which already included results from Bierer et al. (2015); Chur-Hansen (1999); Guerrasio et al. (2014); Katz et al. (2013); Rowland et al. (2012), under the Goals and planning BCT. With these combinations, the pooled number of interventions increased to seven, and the strength of recommendation was elevated from moderate to strong ($n=7$, Strong).

The level of recommendation did not change for other combined interventions.

Total data set of interventions

In total, the dataset of interventions in this updated review, combined with the 2019 BEME, consisted of 121 thematic content data published between 1991 and 2021. The distribution of recommendations under each BCT grouping is presented in Figure 6.

Discussion

Interventions aimed at factors contributing to academic difficulties

This review identified nineteen interventions aimed at addressing academic difficulties among undergraduate and postgraduate medical learners, with twelve introducing new thematic content. For each of the retrieved interventions, the level of recommendations was established. The purpose of this update was to provide a 5-year update, building upon the data obtained from the previous version of the BEME systematic review.

New interventions encompassed a range of main BCTs, emphasizing the theoretical value of Michie's taxonomy (Michie et al. 2015). Notably, the Feedback and monitoring BCT was still more prevalent in interventions targeting postgraduate learners. This disparity could be attributed to the nature of postgraduate training, which frequently involves individualized clinical teaching in one-on-one settings (Ramani and Leinster 2008).

For the first time, the Identity BCT has been matched with an intervention specifically designed to address crucial aspects of professional identity formation and cultural medical practice among postgraduates. Given its potential to foster not only professional identity but also professionalism, which constitutes a fundamental core competency for physicians (Olive and Abercrombie 2017; To et al. 2021), further investigations are warranted to explore interventions utilizing this specific BCT.

Like the previous review, only three BCTs - Comparison of outcomes, Covert learning and Self-belief - did not match as a major BCT for the retrieved interventions. While Morbidity and Mortality Conferences could serve as opportunities to learn from medical errors, complications, and unanticipated outcomes under Comparison of outcomes, they have not been specifically tested for learners with academic difficulties. Covert learning, although not identified as a major BCT in any intervention, may have been employed in *reflective writing* interventions involving the Feedback and monitoring BCT, where learners engaged in self-reflection regarding desired and undesired behaviours and their respective consequences. Self-belief, encompassing persuasion about capability and visualization techniques might have been used in regulation and mentoring interventions involving the Social support BCT.

Educational diagnosis

This section highlights twelve out of the nineteen interventions introduced in this update, emphasizing those that incorporated new thematic content along with their recommendation level. The goal is to offer a more comprehensive understanding of the novel aspects introduced in this updated BEME review.

Learning environment

Interventions focusing on the learning environment were scarce and came from only one study assessing the impact of two interventions, *communication skills workshop* and *culture and transition workshops*, on postgraduate learners (Anderson et al. 2017). While positive outcomes were

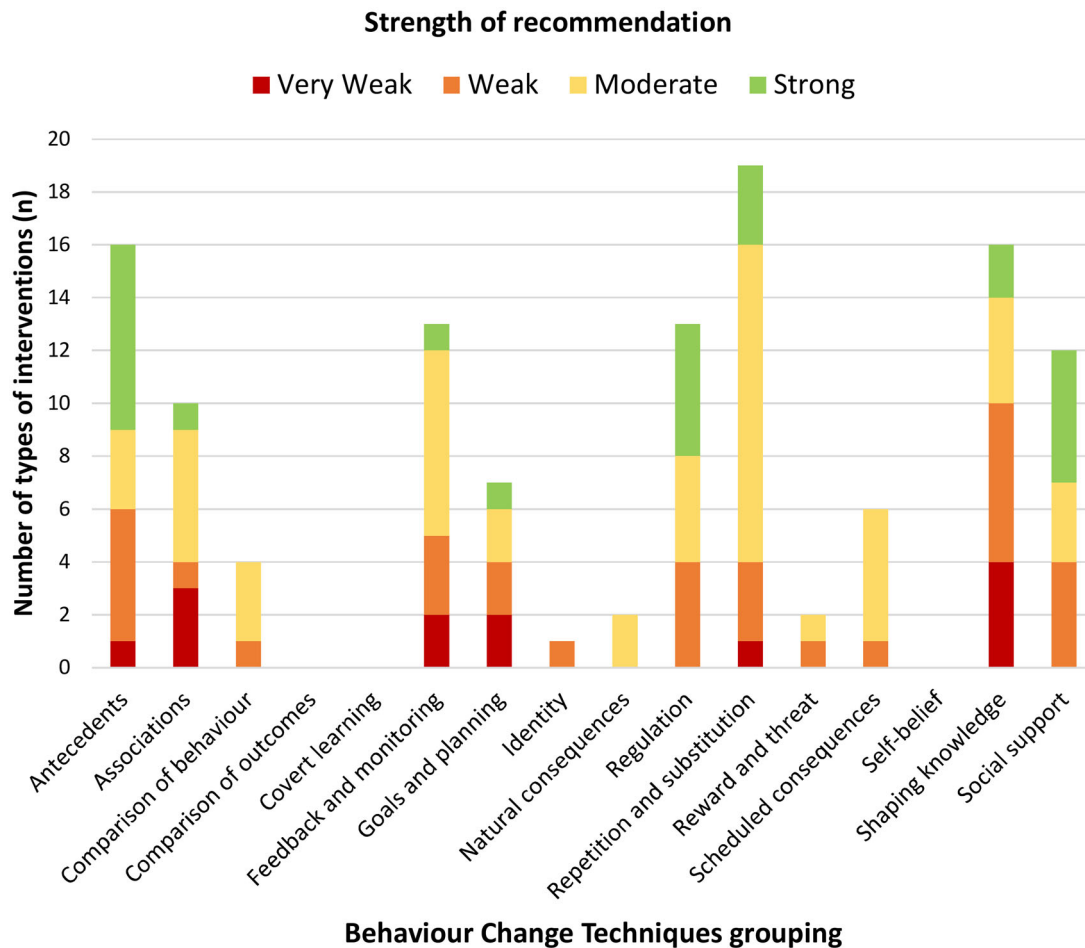


Figure 6. Strength of recommendation of updated data interventions classified by behavior Change Techniques grouping ($n = 121$). This table represents the total dataset of interventions published between 1991 and 2021. It combines information from the 2019 BEME and the new 18 articles of this update.

reported, the strength of recommendations is weak. Considering that medical learners must learn to manage distress and adjust to perceived challenges in their learning environment, further research should explore interventions at the program or hospital levels to provide a psychologically safe learning environment, particularly for medical students with academic difficulties, as suggested by a recent guideline on remediation in medical education (Chou et al. 2019).

Teacher

This review found only one intervention focusing on teacher-specific interventions, which involved the development of a mobile application to assist clinical teachers in effectively describing clinical reasoning difficulties (Boileau et al. 2019). Echoing this, a recent study introduced tools to help clinical teachers diagnose and coach learners' clinical reasoning difficulties (Gagnon et al. 2020). While Gagnon et al. (2020) concentrated on tool development; the effectiveness of these tools has not been assessed. Further research should then evaluate how technology and clinical tools can effectively enhance teaching methods for learners facing difficulties.

Learner

This review examined seven interventions that targeted **learners' personal issues**, utilizing different BCTs such as Feedback and monitoring, Goal and planning, Identity, and

Social support. The evaluation for potential distractors was highlighted as a crucial initial step in the 7D's model by Decoteau et al. (2018). These potential distractors were defined to include personality Disorders, Diseases, sleep Deprivation, learning Disabilities, Drugs and alcohol, Depression, and life Distractions. This strategy is congruent with the Common Program Requirements (Residency) of 2022, as published by the Accreditation Council for Graduate Medical Education (ACGME 2020). It prompts recognition of impairment from different factors including illness, fatigue, and substance use, within residents, their peers, and other healthcare team.

Cultural adaptation poses a significant challenge for at-risk learners, particularly among international graduates. Induction programs have been found to be beneficial in facilitating the cultural transition (Chen et al. 2011; Lineberry et al. 2015; Kehoe et al. 2016; Chou et al. 2019). This review highlights a new article by Anderson et al. (2017) that explored an enhanced induction program, consisting of workshops on clinical skills, cultural understanding, and transition. The objective was to proactively provide these learners with the necessary support to navigate and adapt to the medical education environment.

Knowledge

No new intervention specifically targeted a knowledge educational diagnosis alone. Instead, all interventions were associated with skills problems and/or attitude problems. This might be explained by the fact that knowledge is

often assessed at the beginning of the remediation process to identify learners who are struggling. Many programs utilize *knowledge examinations as benchmarks* to identify learners in difficulty before implementing individualized remediation strategies (Margolis and Ku 2021; Morris-Wiseman and Nfonam 2021). As reflected in this review by Decoteau et al. (2018), poor performers in surgery were defined as participants scoring at or below the 30th percentile on annual American Board of Surgery In-Training Examination exam.

Unpredictably, only one new intervention was categorized under the Shaping knowledge BCT, which involved *structured weekly reading assignments and quizzes* (Wasicek et al. 2019). The limited number of interventions under this category could be attributed to the *necessity of expert facilitation for conveying knowledge*, as supported by guidelines on remediation in medical education (Chou et al. 2019). This could lead consequently to the classification under alternative BCTs. This concept is present in all new interventions reviewed. In fact, interventions categorized under the Social support BCT involved soliciting experts to coregulate learning (Yonder and Pandey 2021) and mentor for test-taking skills (Decoteau et al. 2018). Additionally, *communication skills workshops* (Anderson et al. 2017) and *support for clinical skills assessment* (Hawkrigge and Molyneux 2019) under the Feedback and monitoring BCT seemed relevant in improving performance for Membership of the Royal College of General Practitioners (MRCGP) examinations and was led by facilitators and educators. Finally, a *deliberate practice-based remediation program* (Moon et al. 2019) under the Repetition and substitution BCT, which offered immediate feedback and opportunities to repeat performances with experts, showed improvements in clinical performance scores.

Skills

This review examined thirteen interventions that addressed the educational diagnosis of skills, employing a variety of BCTs. This diversity can be attributed to the comprehensive definition of skills, which encompasses both *cognitive aspects* (such as history-taking, physical examination, clinical knowledge, and clinical reasoning) and *elements beyond cognition* (like professionalism and communication), as defined by Saxena et al. (2009).

Examination skills were improved through *structured weekly reading assessments and quizzes* (Wasicek et al. 2019) under the Shaping knowledge BCT as well as *mentoring for test-taking skills* (Decoteau et al. 2018) under the Social support BCT. Improvement in *long-term clinical skills exams* was observed through a *hybrid coaching model that combined deliberate practice and coregulated learning* (Yonder and Pandey 2021) under the Social support BCT. *Clinical skills* progress resulted from a *deliberate practice-based remediation program* (Moon et al. 2019) under the Repetition and substitution BCT. These interventions may be motivated from the observation that struggling learners often lack engagement in self-regulated learning (Kalet et al. 2016; Kazevman et al. 2021).

Recent guidelines on remediation in medical education suggest to “develop a robust feedback culture that impels learner improvement” (Chou et al. 2019). Feedback and monitoring BCT was used to remediate *clinical skills* by

Hawkrigge and Molyneux (2019) in intervention *clinical skills assessment support*. Additionally, this BCT was employed to remediate *communication skills* by utilizing role-play scenarios and interactions to promote active listening skills (Anderson et al. 2017).

Surprisingly, for the first time, an intervention was matched under the Identity BCT. It addressed *professional skills* by offering a *culture and transition workshop* (Anderson et al. 2017). Professional identity, as described by Olive and Abercrombie (2017), empowers learners to think, behave and feel like physicians. Consequently, developing a professional identity may facilitate the application of clinical skills.

Attitude

This review addressed attitudinal problems in the area of *academic procrastination by acceptance and commitment therapy* (Armani Kian et al. 2020) under the Regulation BCT. The intervention resonates with the concept of *involvement* as outlined in a recent AMEE guide by Mak-van der Vossen et al. (2020) on unprofessional behaviour in medical school. This guide helps medical educators to identify unprofessional behaviours among medical students using the 4 I's model: *involvement, integrity, interaction, and introspection*. Most attitudinal interventions have involved *interaction and introspection* concerns, employing remediation strategies like communication workshops (Anderson et al. 2017) and reflective writing (Findyartini and Sudarsono 2018; Moniz et al. 2022). Nevertheless, given its comprehensive coverage of an entire domain of unprofessional behaviours, it becomes important to explore strategies for addressing concerns related to *involvement*. These concerns encompass a variety of behaviours, including being absent or late for assigned activities, failing to meet deadlines, demonstrating limited initiative, lacking organizational skills, taking shortcuts, showing poor teamwork, and facing language difficulties (Mak-van der Vossen et al. 2020).

Furthermore, this review also addressed attitudinal concerns related to *professionalism lapses*. Mak-van der Vossen et al. (2019) proposed a *three-phase approach to address professionalism lapses*, which was determined to have “very weak” strength of evidence. Similarly, Findyartini and Sudarsono (2018) utilized a *remediation course for professionalism lapse*, which was determined “weak” and Moniz et al. (2022) studied *reflective writing to remediate professionalism*, which was also considered “very weak”. These findings align with the conclusions of a systematic review on remediating professionalism lapses in medical students and doctors, which indicate that there is a lack of established best practices in this area (Brennan et al. 2020).

Strengths and limitations of the review

This review employed the same methodology as the previous study, enabling the combination of results and facilitating a comprehensive analysis. Additionally, the review benefited from international representation and expertise to analyse and evaluate new interventions for undergraduate and postgraduate medical learners with academic difficulties.

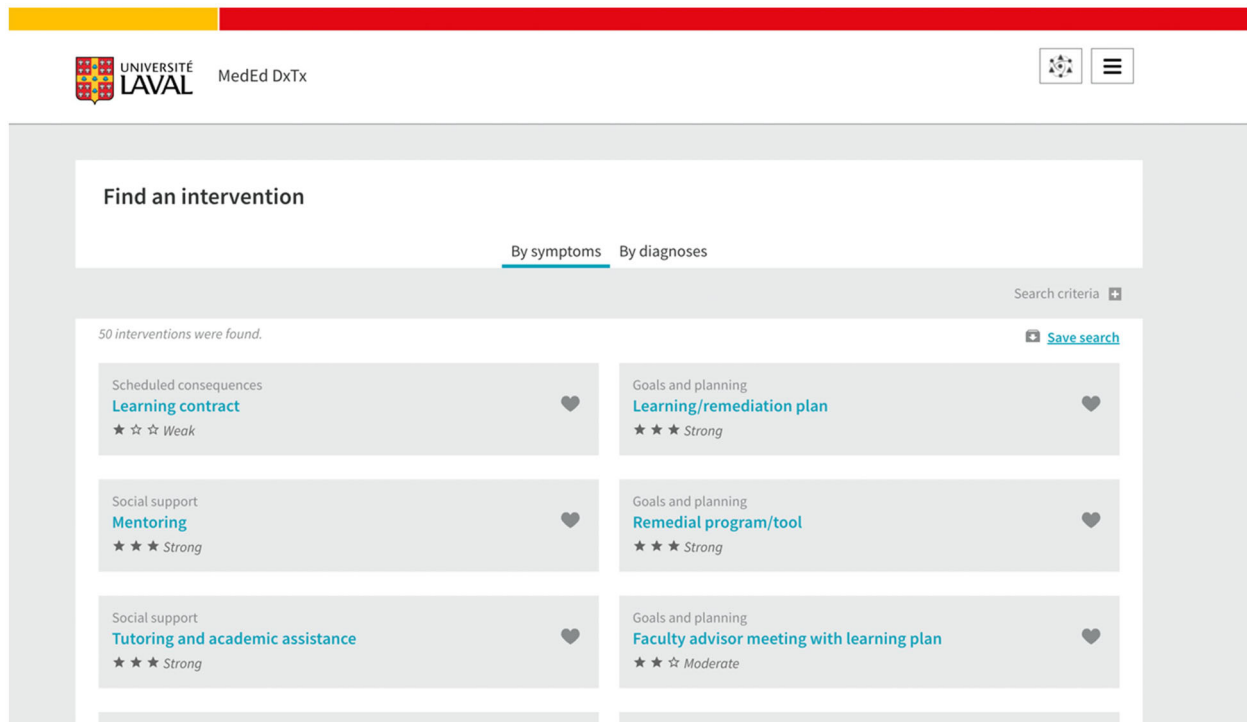


Figure 7. The MedEd DxTx application. Selection of interventions with their level of recommendation.

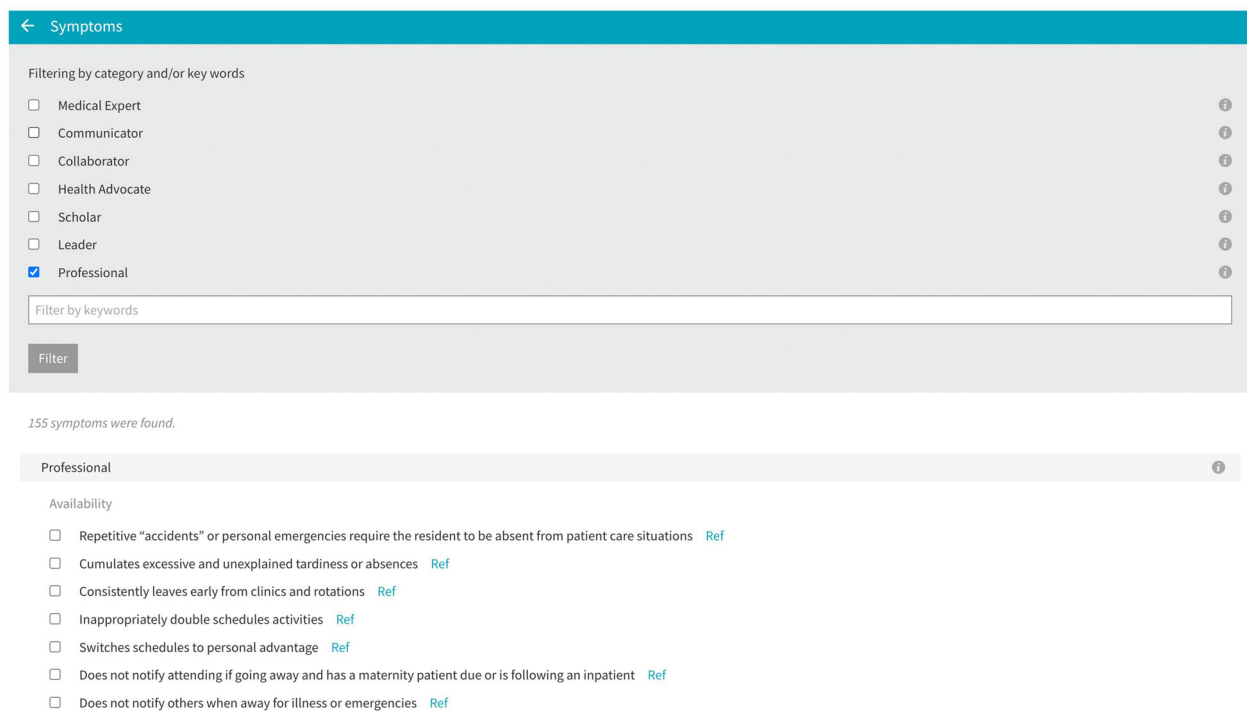


Figure 8. The MedEd DxTx application. Selection of learner's symptoms.

As in the original review, to minimize potential bias, multiple random pairs of reviewers were involved in the data extraction process. Discrepancies in coding were submitted to a second pair of reviewers (JM and ML) for final decisions. This approach enhanced the reliability and objectivity of the review.

Another strength of this review is the use of a structured online software, which facilitated the standardization of data extraction and allowed inclusion of a new research design. Clear definitions of each BCT were provided, promoting a better appropriation of the different concepts, and intra-class coefficients indicated excellent reliability

between coders. New Intervention data confirmed or improved previous recommendations.

However, this updated review also has certain limitations. The review process reflected a 5-year update of the literature from 2016 until 2021. This update can be susceptible to the time lag bias, when interventions with positive results can be published more quickly than those with null or negative results (Sharma et al. 2015). Also, all articles were found in the English language with a majority from North American literature resources. A single reviewer initially screened titles and abstracts, introducing a potential for subjectivity. To minimize bias, articles were not excluded at this stage,

especially when relevance was uncertain. Instead, another independent reviewer assessed them.

Few articles assessed multicomponent interventions, therefore making it difficult to know which components are individually effective. In such cases, a halo effect occurs for certain interventions. As an example, we have now paired the BCT identity for the first time, resulting in a weak recommendation. Nevertheless, intervention within this category originates from the same multi-component study. Subsequent studies should attempt to isolate interventions, enhancing our comprehension of their distinct effectiveness.

The method of calculating MMAT scores might contribute to the moderate inter-rater agreement observed. For each article, the failure to meet either of the two initial methodological quality questions results in a score of zero percent. Subsequently, even if the article fulfills some or all the methodological quality criteria, its score remains zero. This inconsistency in scoring may lead to significant variations among different coders' assessments. Nevertheless, the selection of this tool was deliberate, considering its specific design for the concurrent evaluation and

description of studies included in systematic mixed methods research. Furthermore, the utilization of MMAT in this review facilitates the integration of data from the previous edition.

Finally, the codification for the effectiveness of intervention strategies was performed by a unique pair of reviewers (JM and ML), where the inter-rater agreement was excellent.

Operationalizing the results

When faced with learners experiencing academic difficulties, clinical teachers can refer to the evidence-based platform MedEd Dx Tx website (<https://meded-dtx.fmed.ulaval.ca/MedEdDxTx/Login.aspx>) which serves as a resource listing the studied interventions and their corresponding strength of recommendation. This evidence-based platform can help identification of appropriate interventions (Figure 7) tailored to specific educational diagnoses or a learner's presenting problems (Figure 8).

Box 1 illustrates a teaching scenario involving a post-graduate learner experiencing difficulties. The scenario

Box 1. Teaching scenario with a postgraduate learner.

Sabrina, a 24-year-old graduate currently in her PY1 in family medicine, demonstrates advanced clinical reasoning, patient management, and collaboration skills. Despite excelling in these areas, she faces challenges in promptly submitting charting to supervisors. Although her documentation is efficient and comprehensive, it takes days to weeks, even after multiple reminders, before "closing" her notes. These persistent delays have raised concerns among clinical teachers, particularly due to its potential impact on patient safety.

The MedEd DxTx application can assist in identifying learners' symptoms or educational diagnoses and subsequently identify relevant remediation interventions, each associated with its corresponding level of recommendation. In this teaching scenario, the learner's symptoms, educational diagnoses, and relevant remediation interventions are identified through:

- Learner's symptoms according to MedEd DxTx application
 - Quality improvement
 - Does not make personal adjustments in spite of repeated messages from others about performance in the workplace
 - Does not actively look at his/her practice with assessment tools, and implement appropriate changes
 - Charting
 - Does not do charting in a timely fashion, therefore leading to increased risk of inaccuracies and lost information, and delaying availability of information for others involved in care
 - Allows chart completion to back up unreasonably
- Learner's diagnoses according to MedEd DxTx application
 - Knowledge deficits
 - Work setting knowledge
 - Skills deficits
 - Structural skill
 - Attitudinal problems
 - Professional attitude
- Selection of relevant interventions with their level of recommendation according to MedEd DxTx application
 - Learning/remediation plan (Strong)
 - Daily management reviews by quality insurance coordinator (Moderate)
 - Faculty advisor meeting with learning plan (Moderate)
 - Informal discussion with program director (Moderate)
 - Reflection (Moderate)
 - Warning letter (Moderate)
 - Learning contract (Weak)
 - Point system to document unprofessional behavior (Weak)
 - Review of behaviours (Weak)
 - Reflective writing to remediate professionalism (Very weak)

In response to Sabrina's challenges, clinical teachers planned an informal discussion with the program site director. Through this conversation, Sabrina understood the importance of promptly submitting charting to supervisors for patient safety. Following this meeting, Sabrina gained insight into professionalism competency, prompting her to improve her timeliness in documenting her patient care.

highlights how integrating the new articles into the dataset, resulting in a compilation of 121 interventions, each associated with its corresponding level of recommendation, can contribute to remediation in medical education.

Conclusion

Implications for practice

This 5-year update BEME Collaboration offers valuable implications for medical education practice. The study focuses on identifying and assessing new interventions for undergraduate and postgraduate medical learners who encounter academic difficulties, connecting them to a theory-based conceptual framework, and providing literature-based recommendations.

The review provides clinical teachers and educators with a comprehensive, updated repertoire of literature-based interventions that can be utilized for various purposes, including assessment, mentoring, and faculty development. By classifying these interventions under BCTs, the review reinforces to enhance the understanding of the underlying theoretical foundations for each intervention, thus facilitating their implementation in practice.

Implications for research

To further advance the field of medication education, future research should prioritize the importance of rigorous program evaluation. This would generate a wealth of data that can be utilized to compute the strength of recommendations for various interventions. There is a need for research focusing on specific interventions at the program and hospital levels, as well as faculty development efforts, to assess their impact on learners with academic difficulties.

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Plans for updating the review

After the publication of this update, the search strategy will be conducted periodically using a priority-setting approach to assess the necessity and relevance of a future update.

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