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How physiotherapists personalize airway clearance in children with primary ciliary dyskinesia.

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How physiotherapists personalize airway clearance in children with primary ciliary dyskinesia.

Introduction

Current literature recommends the personalization of airway clearance technique (ACT) regimens for people with chronic suppurative lung diseases, such as primary ciliary dyskinesia (PCD). However, how physiotherapists navigate cues including the individual's physical and psychosocial presentation, the properties of the ACT regimen and their response to the ACT regimen, remains unknown.

Objective

This study aimed to understand how physiotherapists make decisions in relation to personalizing airway clearance regimens for children and young people with PCD.

Methods

Critical decision method (CDM) interviews were used to explore expert physiotherapists' decision-making during an ACT personalization incident. Six physiotherapists with ≥ 5 years PCD experience, from four specialist centers were interviewed; one-to-one virtual interviews were conducted (duration 55-100 minutes). Data were analyzed using the CDM derived recognition-primed decision model and an ACT personalization model.

Results

Our interviews (n=6) showed all physiotherapists initially found the situation to be familiar, but in most cases the initial expectancies of the physiotherapist were violated. Participants described uncertainty in personalization of ACT regimens. An iterative process was used to

manage the uncertainty and make any modifications to ensure the regimen would likely work prior to implementation. This suggests a need for objective tools to support clinical decision-making. Physical characteristics (age, disease severity, pulmonary and non-pulmonary factors, medications), psychosocial factors (lifestyle, adherence, ability to engage) and treatment-related factors (regimen burden, patient's preference) were commonly considered during personalization. The ACT type, procedures and dosage were personalized for each individual. All physiotherapists undertook mental or physical simulations of their proposed actions and in most cases, this led to regimen modifications.

Conclusion

ACT personalization is a complex, iterative process in which uncertainty can arise. With limited tools to assess the effects of ACT regimens, it remains unknown if uncertainty would be reduced, or personalization changed with the provision of more sensitive outcome data.

Keywords: Airway clearance, personalization, pediatric, primary ciliary dyskinesia

INTRODUCTION

Primary ciliary dyskinesia (PCD) is a hereditary condition estimated to affect 1 in 7,500 globally (Hannah et al, 2022). In PCD structural and functional abnormalities in the cilia lining the respiratory tract cause ineffective mucociliary clearance from birth (Meeks and Bush, 2000). Children and young people with PCD (CYPwPCD) are susceptible to the vicious vortex of impaired mucociliary clearance, infection, inflammation, and lung damage seen in chronic suppurative lung diseases (CSLDs) (Flume, Chalmers & Olivier, 2018). PCD is a heterogeneous condition in the context of clinical manifestation disease severity, and trajectory (Halbeisen et al, 2018; Lucas et al, 2017). Living with PCD can be burdensome for the individuals and their families as symptoms can be stigmatizing (Whalley and McManus, 2006) and treatments are time-consuming (Schofield and Horobin, 2014). Additionally, exacerbations increase parental stress (Rubbo et al, 2020) and result in time off from school and work (Grieve et al, 2011; Suthoff et al, 2019). With no curative treatment currently available, PCD management focuses on the regular surveillance and timely management of respiratory infections and sinonasal and otological disease (Lucas et al., 2017). Airway clearance techniques (ACTs) that aim to augment secretion clearance from the lungs are a core component of PCD management, despite a paucity of evidence to support any one approach (Robson et al, 2026).

Evidence pertaining to ACTs specifically in PCD is limited to three studies. These studies evaluated 1) a single session of positive expiratory pressure (PEP) (Vandervoort et al, 2022); 2) five days of high frequency chest wall oscillation (HFCWO) versus postural drainage with percussion and vibrations (PVPD) (Gokdemir et al, 2014); 3) three-months of oscillatory PEP (OPEP) versus PDPV (Bingol et al, 2020). Significant improvements in forced expiratory volume in the first second (FEV₁)

from baseline was seen with all types of ACT interventions, but no significant difference was seen between the ACT types as assessed by spirometry (FEV₁, forced expiratory volume, peak expiratory flow, forced expiratory flow 25-75%) (Bingol et al., 2020; Gokdemir et al., 2014). Similarly, the short-term benefits of ACTs in CSLDs have been demonstrated by evidence evaluated in two Cochrane reviews (Lee, Burge, and Holland, 2015; Warnock and Gates, 2015). The CSLD literature, appraised by six Cochrane reviews have collectively shown that no single ACT is superior over a 6 month period, in respect of lung function metric, FEV₁ (Wilson, Morrison, and Robinson, 2019), quality of life or breathlessness (Lee, Burge, and Holland, 2017).

ACT regimens should be personalized for individuals (Robson et al., 2026; Schofield et al., 2023), but given the lack of evidence supporting the superiority of any single ACT, clinical decision-making of how to personalize regimens relies on physiotherapists' judgement. These judgements require the skill and expertise of clinicians to interpret information (Thornton, 2006). Cardio-respiratory physiotherapy decision-making has been explored previously in acute care settings (Shkurka, Shannon, Rand, and Wray, 2025; Smith, Higgs, and Ellis, 2010; Thackray and Roberts, 2017). These studies have demonstrated the complexity of decision-making, how physiotherapists draw on a diverse range of information and their prior experiences to iteratively work through complex reasoning. As iterative refinement of interventions requires the assessment of treatment response (Shkurka, Shannon, Rand, and Wray, 2025; Smith, Higgs, and Ellis, 2010; Thackray and Roberts, 2017), there may be differences in decision-making process between acute settings where treatment response can be assessed quickly, and long-term condition management, where this may be more protracted. To date, no studies have explored physiotherapy decision-making when personalizing ACT regimens in CSLDs. The factors to be considered when

personalizing ACTs in CSLDs have been identified through a scoping review of current literature; these include physical presentation (age, diagnosis, disease severity, pulmonary and other physical factors), psychosocial factors (preference, adherence, engagement, lifestyle, treatment burden) and regimen response (Schofield et al., 2023). Whilst an initial model of ACT personalization in CSLDs based on current literature has been presented (Schofield et al., 2023), this model has yet to be tested in a real-world context. As such, this study aimed to understand how physiotherapists make decisions in relation to personalizing ACT regimens for CYPwPCD.

MATERIALS AND METHODS

Cognitive Task Analysis (CTA) methodology can be used to uncover how experts make decisions in complex situations and is increasingly used in applied health research (Swaby, Shu, Hind, and Sutherland, 2022). Personalized care is complex and difficult to evaluate, therefore, CTA methods used to explore decision-making in real-world complex circumstances (Crandall, Klein, and Hoffman, 2006) are appropriate for this enquiry. Critical decision method (CDM), which resides in CTA methodology, is a structured interview technique specifically designed to probe experts' decision-making during challenging incidents through progressive questioning about critical decision points, cues, and alternative actions considered. The CDM derived recognition-primed decision model (RPDM) provides a theoretical framework for understanding how experts make decisions in naturalistic settings (Klein, 1993). Unlike traditional decision-making models that assume systematic comparison of options, the RPDM proposes that experienced practitioners recognize patterns from previous encounters, rapidly matching situations to stored mental models and simulating potential outcomes before acting. The RPDM is particularly relevant to ACT personalization as physiotherapists must recognize patterns in patient responses—such as ease of secretion clearance or breathing pattern—during

treatment sessions and rapidly adjust techniques, positioning, or device settings based on their accumulated experience with similar clinical presentations (Schofield et al., 2023). This study used CDM, a specific CTA technique to elicit detailed narratives about non-routine clinical incidents where experts' decision-making diverged from standard practice - precisely the challenging situations where ACT personalization becomes most complex (Crandall, Klein, and Hoffman, 2006).

Sample

All expert physiotherapists (minimum five years clinical experience, including two in respiratory) working within the English pediatric PCD specialist centers were approached by email. Recognizing this as a homogenous group of experts, a target sample size of six was set with the aim of achieving theoretical data saturation (Guest, Namey, and Chen, 2020), a point at which data analysis does not yield any new theoretical information (Morse, 1995). Six out of seven clinicians approached participated, no new concepts were identified during analysis of the sixth case. Ethical approval was in place for this study (Oxford B research ethics committee, 21/SC/0197, 9th July 2021), all participants provided written informed consent. All participants were aware this study was being completed as part of the lead researcher's (LS) PhD.

Interviews

One-to-one interviews were conducted by the lead researcher (LS) using Microsoft Teams and interview audio captured with an encrypted Dictaphone. Field notes comprised an initial timeline that documented during the initial interview stages. Interviews lasted between 55-100 minutes. An interview schedule (Table S1, supplementary file) based on the CDM four "sweep" approach (Crandall, Klein, and Hoffman, 2006) was used to gain progressively more detailed information. The initial incident identification involved inviting the participant to suggest an example of where

they made a complex decision regarding ACT regimen personalization for a CYPwPCD. Their overview provided the basis for subsequent sweeps. The second sweep was used to construct a timeline; during this sweep a more detailed account of the incident was used to produce a timeline with critical points where the situation could have changed depending on the decision made at that time. Then, progressive deepening permitted an exploration of the physiotherapists' perceptions, expectations, goals, judgments, and uncertainties, particularly at the critical timeline points, including options considered and information needed. Finally, "what if" queries: for each point already discussed, the interviewee considered what they might have done differently, and if they had, what would have happened. Case notes were not accessed to verify the accuracy of the clinical case. For member checking, participants were invited by email to review and provide feedback on the initial case timeline following the interview (Rolfe, Ramsden, Banner, and Graham, 2018); feedback included timeline clarification (n=3), or timeline confirmation (n=2). No follow up interviews were undertaken.

Data analysis

The analytical approach reflects an ongoing cycle of inference (Bolton, 2015). The ACT personalisation model was developed in a prior scoping review (Schofield et al., 2023) through a process that moved from the deductive application of the TIDieR framework (Hoffmann et al, 2014) through inductive identification of personalisation factors, to the abductive construction of a model explaining the relationships between them. In the present study, this model and the RPDM (Klein, 2008; Klein, 1993) were applied to interview data, providing structure for coding. However, consistent with Peirce's account of inquiry as self-correcting (Bolton, 2015; Timmermans and Tavory, 2012), the analytical process remained open to surprises in the data that warranted further revision and integration of the frameworks. Interviews were transcribed by the lead

researcher (LS) and coded to these two complementary frameworks: the CDM-derived RPDM (Figure 1) (Klein, 2008) and the ACT personalization model (Schofield et al., 2023) (Figure 2). The ACT personalization model was developed by the lead author based on the findings of a scoping review on the personalization of ACTs in CSLDs. This model was used to provide a context specific secondary analysis. Coding and analysis followed the CDM phased analysis method (Crandall, Klein, and Hoffman, 2006): preparation, structure data, discover meaning, represent key findings. Coding trees for the RPDM and ACT personalization model analysis are provided in Figures S1 and S2 respectively (supplementary file). The case timelines were used to identify any decisional points during the case incidents, where the physiotherapist's understanding or action affected the subsequent events and alternative understanding or actions were available (Crandall, Klein, and Hoffman, 2006). These decisional points acted as landmarks, assisting identification of the RPDM stages within each case. Data was coded by the lead researcher (LS) and samples of coded text verified by a highly experienced qualitative researcher (DH).

The two frameworks were selected as complementary because they operate at different levels of abstraction and answer different questions (Bordage, 2009). The ACT personalisation model (Schofield et al., 2023) captures the substantive content of personalisation — the patient factors considered, regimen parameters adjusted, and contextual influences at play. It provides a first-order account of what physiotherapists attend to. The RPDM provides a process-level framework explaining how experienced practitioners navigate complex decisions through pattern recognition, expectancy violation, and mental simulation (Klein, 2008; Klein, 1993). In RPDM terms, expectancy violations are moments when the familiar situation becomes unfamiliar - such as a patient responding unexpectedly to a usually effective technique - requiring

the clinician to step back from routine practice and actively problem-solve. Together, these frameworks enabled analysis of both what physiotherapists consider during personalisation and how they reason through those considerations.

Although coding was initially structured by the two frameworks, the analytical process was not closed to new insights. When coding revealed that the RPDM's process components systematically mapped onto and enriched the ACT personalisation model, this prompted a further abductive process (Bolton, 2015) the integration and revision of the model as the best available explanation of the data. Following analysis of all transcripts, the ACT personalization model and RPDM were integrated using NVivo (1.7.1, Lumivero, Dever, USA). Coding stripes were used to identify the transcript sections coded to both models and those only coded to one model at the level of the case. From this, the codes from both models which commonly occurred together across cases were then identified. Subsequently, physical mapping of the RPDM stages to the ACT model was undertaken. The revised model was then tested against the flow of decision-making in the interview transcripts. The application of the RPDM and ACT personalization model delivered three main analytical outputs: individual case timelines mapped to RPDM stages, cross-case patterns of decision-making processes, and integration of findings into a revised ACT personalization model.

Lead researcher reflexivity statement

The lead researcher is an experienced respiratory physiotherapist who has been working with children with PCD since 2005, and as part of the National PCD management service since 2013. This study was undertaken in partial fulfilment of her PhD. The lead researcher designed and secured funding for the study. As an expert physiotherapist and a colleague of the participants, there is potential this may have influenced both the data collection and analysis. LS had previous qualitative research experience, specifically

using interpretive phenomenological analysis to explore lived experiences. She had no prior experience of using CTA methodology but was the lead researcher in developing the ACT personalization model. Bracketing of prior beliefs and regular reflection were used to minimize the impact of both her clinical and research experience on the analysis.

RESULTS

All physiotherapists were working within the highly specialized pediatric management services, and at least one physiotherapist from each of the four English National PCD centers participated. All were experienced physiotherapists: they each had between 11 and 30 years of clinical experience and their time working as PCD specialist physiotherapists ranged from six months to 10 years.

Recognition-primed decision model analysis

Each physiotherapist suggested a unique case example. Timelines showing RPDM stages and decision points for each case are provided for reader clarity of the clinical contexts in Figure S3 (supplementary file). Example excerpts from the interview transcripts for each of the RPDM codes are provided in Table S2 (supplementary file). A cross-case analysis based on the RPDM is shown in Figure 3.

All clinicians initially found the situation familiar, the quote below demonstrates how they used cues to form goals: *“His lung function had dropped...he was quite crackly...clearing more secretions...something needed to change”* (Case 3.1).

Divergence between cases arose when initial expectancies were upheld in two cases (Cases 3 and 6) but violated in four (Cases 1, 2, 4 and 5). When expectancies were violated, initial courses of action were reconsidered as the physiotherapists recognized the situation was not familiar: *“I wouldn’t normally give somebody an incentive*

spirometer for airway clearance, but Mum had...said that it was really helpful...so it was really interesting...to actually work out what's going on." (Case 1.2). Seeking further information (Cases 1, 2, 4 and 5), provided new cues and familiarity to the situation.

All physiotherapists undertook mental or physical simulations of the proposed actions. In five of the six cases, this led to modifications prior to regimen implementation (Cases 1, 2, 3, 4 and 6). Descriptions of the process of personalization highlighted its iterative nature, for example when trialing the regimen provided further information: *"If I change the way he's huffing...that's treatment, but it's assessment as well"* (Case 3). Clinicians had confidence in using their experience to guide their decisions. Whilst they highlighted the limitations of spirometry (Cases 1 and 3), multiple breath washout metrics (Case 3), and the potential role of MRI to inform practice (Cases 3 and 6), peer advice was likely to be chosen over technologies (Case 5).

Participants described uncertainty in personalization of ACT regimens: *"It's sort of having a stab in the dark, but...with experience behind you"* (Case 2). This suggests a need for objective tools to support clinical decision-making. Whilst uncertainty was seen across the group, including in those with more experience, most of the expert physiotherapists felt novices would have taken a different path through the incident. The reasons for this included: missing subtle changes in signs or symptoms (Cases 1, 3, 4, 6), through inadequate probing (Cases 1 and 3); by potentially not using a "multisystem" approach (Cases 2 and 4); lacking confidence to implement changes to optimize regimens (Cases 1, 3, 5 and 6).

Airway clearance technique personalization model analysis

Example excerpts from the interview transcripts for each of the RPDM codes are provided in Table S2 (supplementary file). The ACT personalization model themes featured within all interview transcripts (Table S3, supplementary file). All

physiotherapists drew upon their assessment of a broad range of physical characteristics including age (n=6), disease severity (n=6), pulmonary factors (n=6), PCD specific factors (n=5), non-respiratory factors (n=5) and non-airway clearance medications (n=3). Psychosocial factors: the individuals' lifestyle, adherence, and ability to engage with the ACT regimen, were considered in all cases. The ACT regimen burden (n=5) and patient's preference (n=5) were also common features.

The ACT type, procedures and dosage were personalized for each individual. Physiotherapists selected or confirmed the ACT type was suitable by considering how difficult it would be to complete (n=4), the environment in which it would be completed (n=5), the device features (n=4), any contraindications or precautions (n=4) and availability of resources (n=5). The intervention procedures were personalized through combining multiple ACT types (n=6) and by optimizing the sequence of components (n=5). They established the device settings (n=3) and worked to optimize the patient's technique (n=6). The unit repetition was either specified or varied based on symptoms. The dosage of the intervention was discussed in all cases. The individual's response to the ACT regimen was assessed both during (n=5) and following the intervention (n=6), with specific awareness of an adverse response during two reviews. In each case the physiotherapist considered when they would next have the opportunity or need to reassess the patient. The physiotherapists, as the "provider" of the ACT recommendations described how their experience may influence their practice (n=6), and how location could also influence the regimen (n=4).

Airway clearance technique personalization model progression

The revised ACT personalization model which integrates the RPDM components is shown in Figure 4. Patient physical and psychosocial factors were the cues obtained by the physiotherapists to identify the situation as familiar; goals were informed by

individual patient factors (Box C) and were set in the context (Arrow B>X) of the “providers” expectancies (Box B). Patient factors informed adaptations or prompted the physiotherapists to modify the interventions (Arrow C>D). Trialing the regimen were the physiotherapists’ actions (Arrows D>E and B>X). Response provided further information on “will it work” (Arrow E>C). When expectancies were violated, the physiotherapist moved outside of the iterative loop of personalizing within clinical encounters; such instances provided an opportunity for experiential learning (Arrow X>B).

DISCUSSION

This study explored how expert physiotherapists personalize ACT regimens for children with PCD. By employing CDM methodology, we made the tacit decision-making processes of expert physiotherapists explicit. We found expert physiotherapists personalize ACT regimens through iterative cycles of assessment and adaptation, managing uncertainty as it arises and drawing upon their experience to implement regimens.

The recommended standards for ACTs outlined in a recent PCD management consensus document resonate with the current study: individualized ACT regimens and reviews with a specialist physiotherapist. Given the limited evidence on the effectiveness of ACTs specifically for PCD, practices are largely guided by clinical experience, physiotherapist initiative, and patient characteristics. The evidence gaps mentioned in this consensus highlight the value of the present work, which offers real-world data on decision-making processes and personalization strategies.

This enquiry found that situations initially appear familiar to experts when personalizing ACT regimens, but that uncertainty often subsequently arises. Uncertainty is common across healthcare settings, especially when recommending treatment

interventions (Pomare et al, 2019) and decision makers must manage this uncertainty (Crandall, Klein, and Hoffman, 2006). There were examples of the common uncertainty management strategies (Lipshitz and Strauss, 1997) being employed by the physiotherapists in this study. Uncertainty was reduced through seeking more information; it was suppressed by implementing an “interim” regimen; it was accepted, balancing pros and cons to implement a regimen. Reducing uncertainty by anticipating potential problems is a strategy previously reported in respiratory physiotherapists working in intensive care (Mishoe, 2003). In this study, the physiotherapists anticipated potential problems by either mentally simulating or piloting the ACT regimen to understand if it would work, reduce uncertainty, and modify regimens as needed. As mental simulation requires experiences the individual to drawn upon their experience (Flin, Youngson, and Yule, 2007), it may be influenced by the individual clinician (Smith, Higgs, and Ellis, 2010), and may prove more difficult for novices who may overlook important cues or lack confidence in their decision (Helou, DiazGranados, Ryan, and Cyrus, 2020).

Previous studies (Smith, Higgs, and Ellis, 2007; Thackray and Roberts, 2017) have captured cardio-respiratory physiotherapy decision-making in acute settings where response can be immediately assessed. This study for the first time explored decision-making in relation to prospective and on-going home-based treatment recommendations. In this clinical context, physiotherapists are limited to predicting if an on-going home-based treatment will be effective through mentally simulating or piloting the regimen. Establishing if ACT regimens are likely to be effective becomes more difficult in the absence of both outcome measures that are sensitive to assess the effects of ACTs and clinical-prediction rules (Childs and Cleland, 2006). Both Smith, Higgs and Ellis (2007) and Thackray and Roberts (2017) included participants with a

range of clinical experience, the current study population was limited to experienced physiotherapists. Whilst including more junior colleagues would have facilitated generalization to a wider clinician group, many key features of the previous studies were seen in our findings including identification of cues, actions, goals, and response evaluation; the influence of provider experience; iterative decision-making.

CDM has previously been used to explore cardio-respiratory physiotherapy decision-making (Smith, Higgs, and Ellis, 2010; Thackray and Roberts, 2017). This study for the first time employed CDM to explore the more specific context of ACT personalization, providing new insights into decision-making of physiotherapists in a CSLD. Our findings further validate the RPDM's applicability to physiotherapy, demonstrating how experienced clinicians use recognition-primed strategies to navigate the inherent uncertainty of personalized care. The RPDM framework demonstrated strong explanatory depth (Keas, 2018) by showing how expectancy violations disrupted the decision-making flow and identifying transition points where clinicians stepped out of the iterative tacit decision-making loop to draw upon the best available evidence.

Approaching the analysis from two perspectives illuminated different aspects of the data (Bordage, 2009), the strengths of each model supported the limitations of the other. This study represents a further stage in an ongoing cycle of inquiry (Bolton, 2015; Timmermans and Tavory, 2012). The ACT personalisation model, itself developed through a cycle of deductive, inductive, and abductive inference in a prior scoping review (Schofield et al., 2023), was here applied alongside the RPDM to structure coding. Where the data suggested that these frameworks intersected — with RPDM process components mapping onto the ACT model's content — this prompted further revision of the model (Figure 4), to produce a model that encompasses literature from two distinct fields: ACT personalization and decision-making. This self-correcting

movement through stages of inference is consistent with Peirce's account of inquiry (Bolton, 2015) and with the iterative logic of framework analysis (Ritchie and Spencer, 2002). Integrating the models has provided greater insights, elevating the model from one of purely ACT personalisation, to one which embeds the language of decision-making and producing a more explicit understanding of the process. The updated model helps to differentiate between ongoing clinical encounters, where expectancies are upheld and the physiotherapist fluidly moves around the iterative loop of ACT personalisation, and instances where expectancies are violated, and a re-evaluation of the situation or further information is needed. Identifying when expectancies are violated may help to distinguish where additional resources such as time, peer support or new knowledge may be needed to optimise decision-making.

Cardiorespiratory physiotherapy decision-making in acute care has been assessed using CDM by Thackray and Roberts (2017) who developed a conceptual decision-making model. Comparing this model with the ACT personalization model: both include assessment, evaluation of response and goals and reflect an iterative process; the model by Thackray and Roberts (2017) places information processing, hypothesis testing and reflection in a balanced central role, whereas the ACT model provides more distinction between the task and the provider; the conceptual model of clinical decision-making in cardiorespiratory physiotherapy pertains to a broader clinical area, and the ACT personalization model pertains to a more specific clinical context. As complementary models they align to promote the importance of understanding clinical decision-making in respiratory physiotherapy.

Implications for practice

The findings of the study are highly relevant to the education and training and development of physiotherapists. With uncertainty during ACT personalization found to

be common in a group of experts, this highlights the importance of having effective ways to recognize and manage uncertainty at all levels. The “lack of information about the effects of treatments” is the most common cause uncertainty in healthcare (Djulgovic, Hozo, and Sander Greenland, 2011 p.306). As physical cues are key components of ACT decision making, the limitations of current assessment tools, such as spirometry, may contribute to uncertainty. If we had better tools to assess outcomes it may be possible to reduce such uncertainty (Lipshitz and Strauss, 1997), however, we cannot determine from this study whether better outcome measures would reduce uncertainty or change personalization approaches.

When the clinical situation did not follow the expectations of the physiotherapist, it presented an opportunity for experiential learning. These opportunities were used to seek new understanding through additional information from reassessment, colleagues, or literature and to re-evaluate the situation. Clinical practice can be subject to time pressures and therefore it is important to consider how to make space within intervention personalization for experiential learning and re-evaluation when situations are not as clinically expected.

Whilst all participants were experienced in PCD management, they identified the potential for more novice colleagues to miss key cues or lack confidence in their decision making. As the range of cues used by physiotherapists mapped across factors in the ACT personalization model, the model may be an appropriate training tool. As novices inherently have a smaller pool of experiences to draw upon when making decisions, support from more experienced or more specialized colleagues is vital, especially in situations where expectancies are violated. This point is reflected by the value placed on at least annual specialized physiotherapy input in the PCD standards of care (Robson et al, 2026).

The implications for physiotherapy education and training here reflect how the CDM approach can direct healthcare training; using critical cues to formulate assessments, develop hypotheses, take actions and assess response (Patterson et al, 2016). This suggests that developing pattern recognition capabilities and mental simulation skills should be prioritized alongside technical knowledge. felt novices would have taken a different path through the incident. The reasons for this included: missing subtle changes in signs or symptoms (Cases 1, 3, 4, 6), through inadequate probing (Cases 1 and 3); by potentially not using a “multisystem” approach (Cases 2 and 4); lacking confidence to implement changes to optimize regimens (Cases 1, 3, 5 and 6).

Limitations

The use of retrospective incidents may have caused inaccuracies, though non-routine cases (Crandall, Klein, and Hoffman, 2006) were used to minimize this risk. The case timelines were verified through member checking; however, the case details were not verified against actual clinical records. Whilst data saturation (Morse, 1995) was achieved, the small and homogenous nature of the sample limits the generalization of the findings. The characteristics of participants were similar; they all worked exclusively within the English national pediatric PCD service, were experienced clinicians and were all female. This potentially limits transferability to other geographical settings and clinical groups. The population of physiotherapists who are experienced in the management of children with PCD is small, extending the inclusion criteria to physiotherapists with relevant experience working in tertiary children’s hospitals in addition to those in the specialist centers may have increased the diversity of participant characteristics. The findings may not have captured all possible decision-making patterns and may not represent the decision-making of less experienced or specialized clinicians.

Future research

Key questions remain about this work. One important issue is whether using more sensitive outcome measures could help reduce uncertainty in ACT personalization. It is also unclear whether the patterns observed in decision-making are consistent across other countries, age groups, and CSLDs. In addition, further exploration is needed to understand how patients themselves experience personalization, as well as the ways in which carers and MDT members influence decisions. Finally, it will be essential to examine how decision-making evolves over the long-term management of the condition.

CONCLUSION

This study has shown how physiotherapists make decisions about personalization in naturalistic settings. The integration of RPDM components into the ACT personalization model represents an important theoretical advance, capturing both the content and process of clinical decision-making in ACT personalization. This study has identified that the personalization of ACT regimens is an iterative process that helps to manage the uncertainty faced by physiotherapists. With limited tools to assess the effects of ACT regimens, it remains unknown if uncertainty would be reduced, or personalization changed with the provision of more sensitive outcome data.

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The authors declare no competing conflicts of interest.

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Figure 1

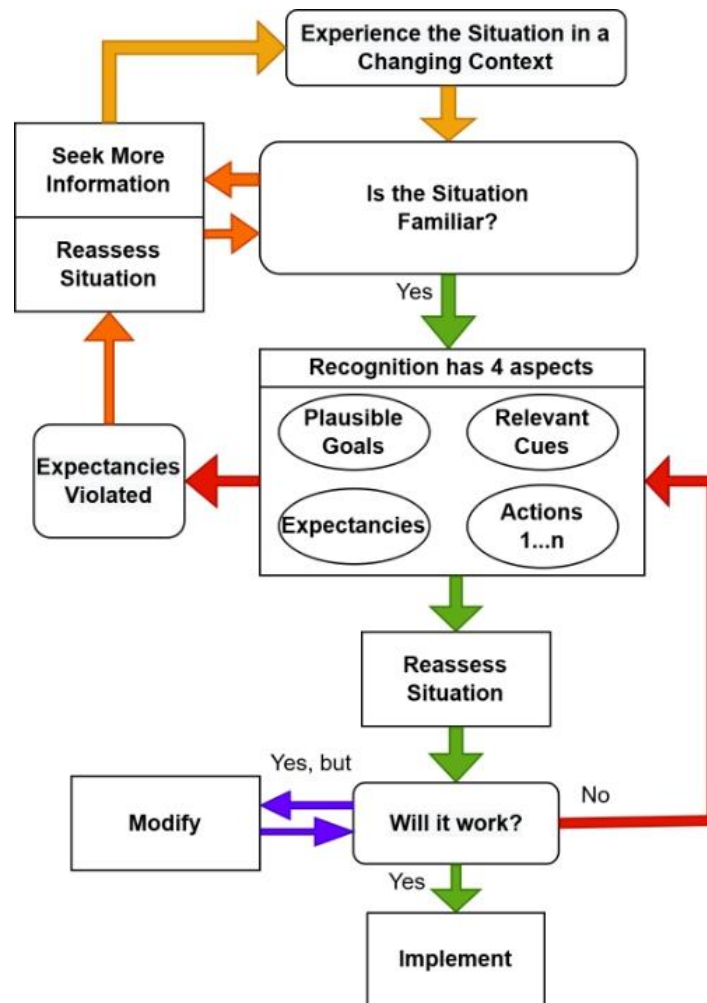
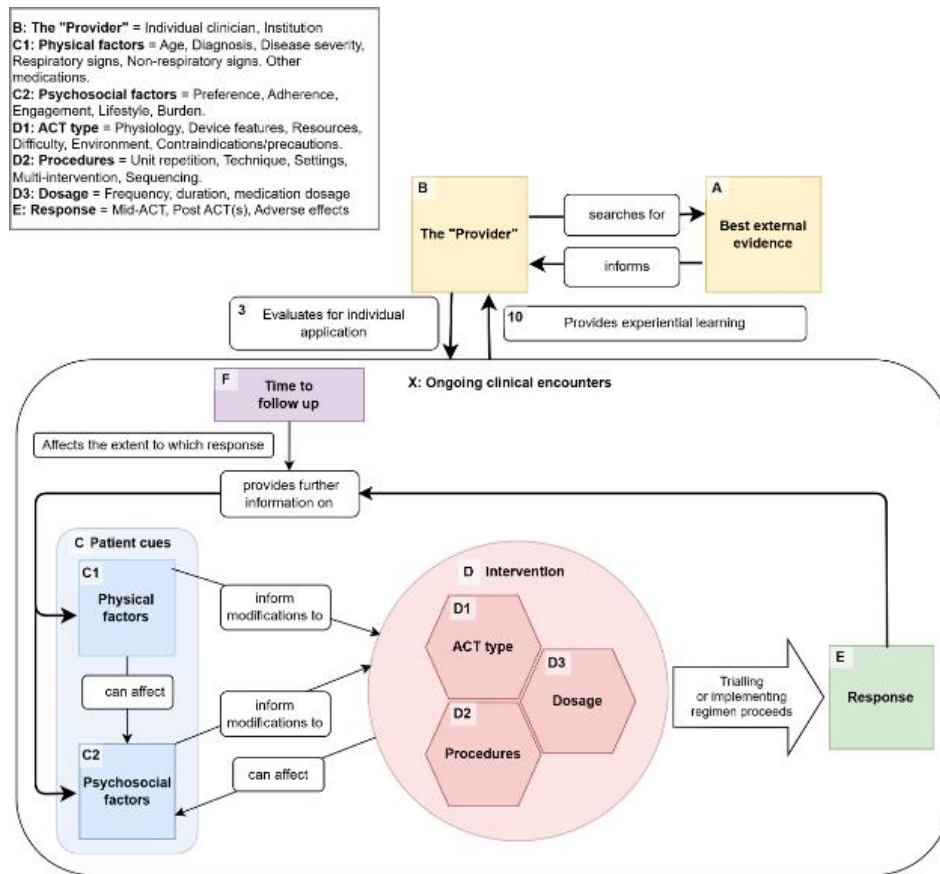


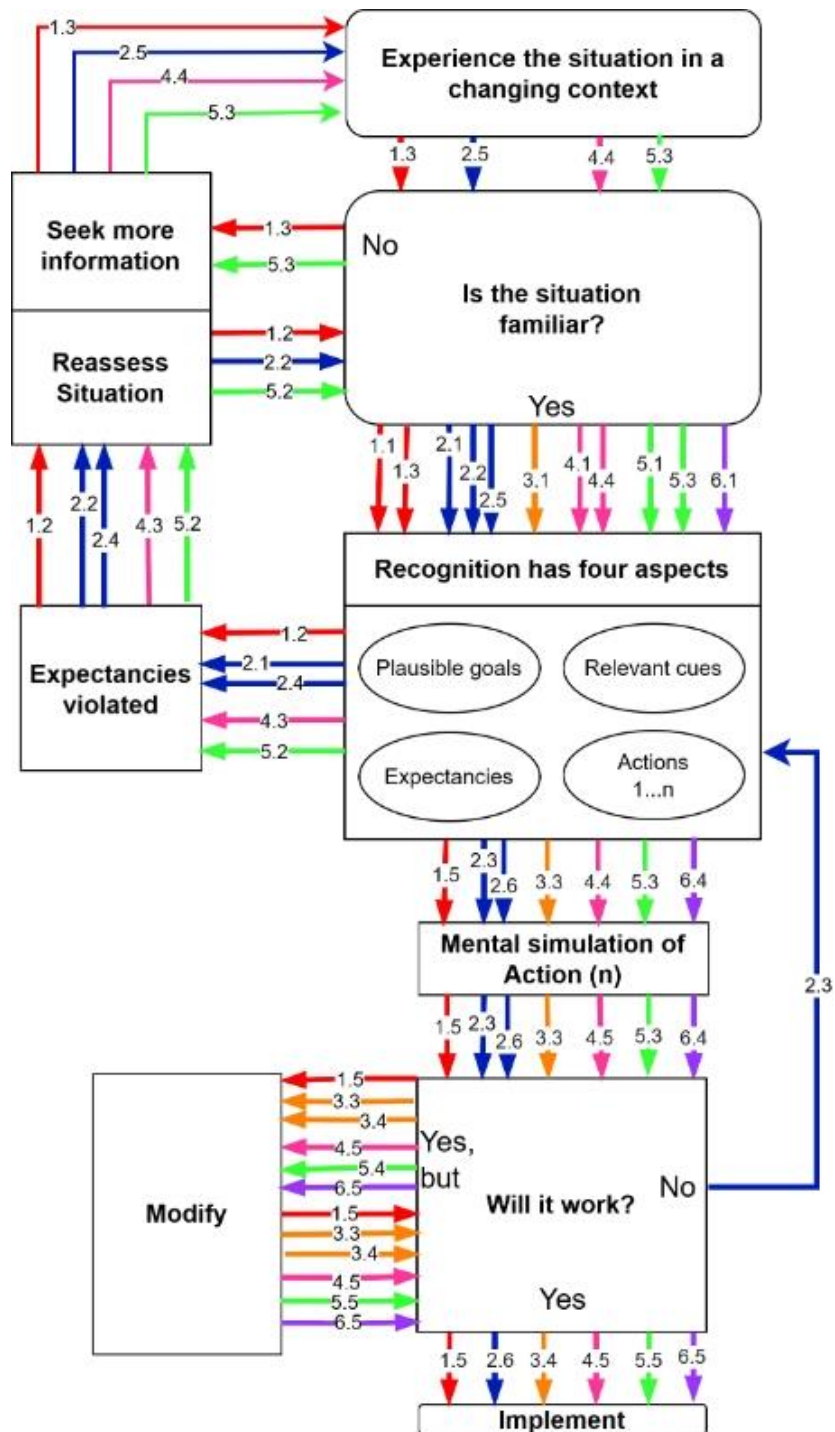
Illustration of the recognition-primed decision model developed by Klein (1993).

Figure 2



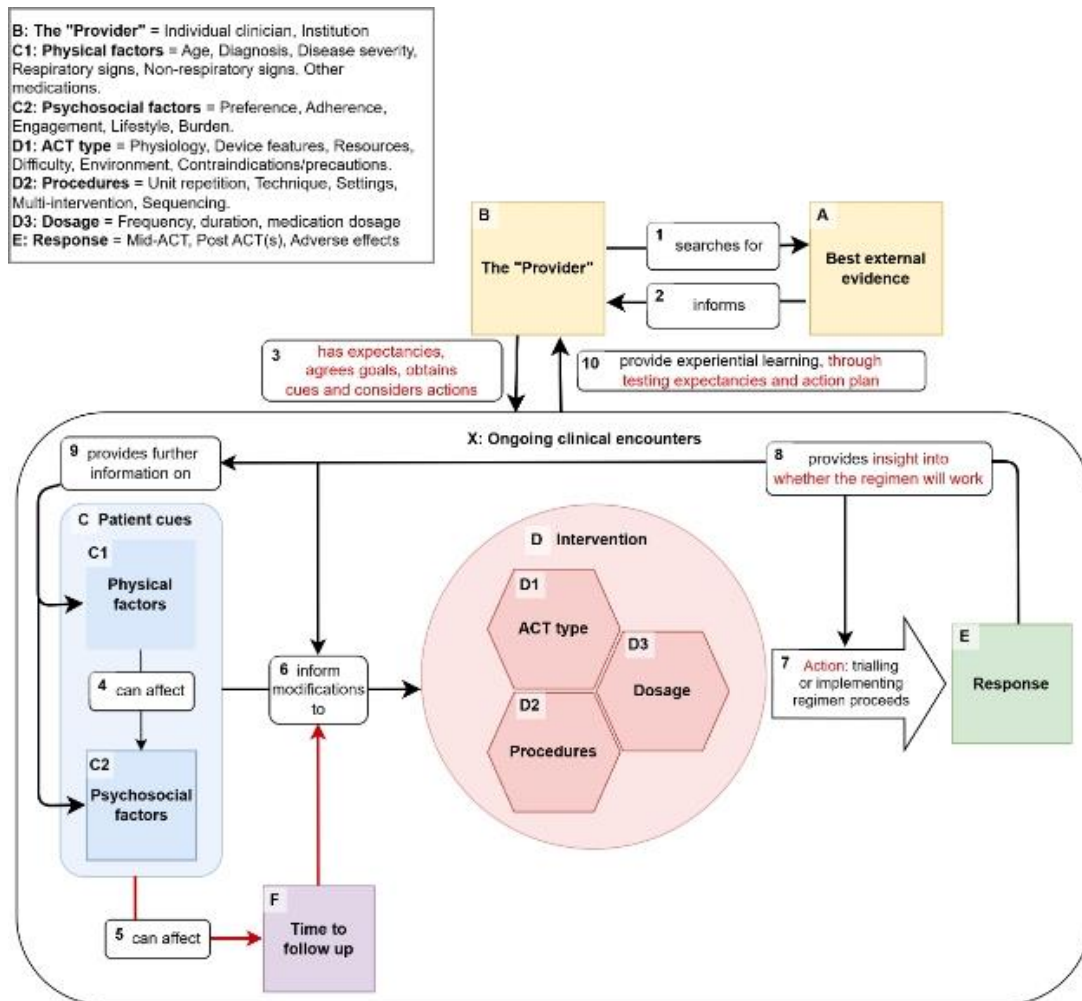
The ACT personalization model version (Schofield et al., 2023), reproduced with permission of the ERS 2026.

Figure 3



Cross-case analysis using the recognition-primed decision model (Klein, 1993).

Figure 4



The updated ACT personalization model (version 0.2). Changes from the previous version by Schofield et al. (2023) are detailed in red.