

Designing a Behaviour Change Wheel guided implementation strategy for a hypoxaemic respiratory failure and ARDS care pathway that targets barriers

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ABSTRACT

Background A significant gap exists between ideal evidence-based practice and real-world application of evidence-informed therapies for patients with hypoxaemic respiratory failure (HRF) and acute respiratory distress syndrome (ARDS). Pathways can improve the quality of care provided by helping integrate and organise the use of evidence informed practices, but barriers exist that can influence their adoption and successful implementation. We sought to identify barriers to the implementation of a best practice care pathway for HRF and ARDS and design an implementation science-based strategy targeting these barriers that is tailored to the critical care setting.

Methods The intervention assessed was a previously described multidisciplinary, evidence-based, stakeholder-informed, integrated care pathway for HRF and ARDS. A survey questionnaire (12 open text questions) was administered to intensive care unit (ICU) clinicians (physicians, nurses, respiratory therapists) in 17 adult ICUs across Alberta. The Behaviour Change Wheel, capability, opportunity, motivation - behaviour components, and Theoretical Domains Framework (TDF) were used to perform qualitative analysis on open text responses to identify barriers to the use of the pathway. Behaviour change technique (BCT) taxonomy, and Affordability, Practicality, Effectiveness and cost-effectiveness, Acceptability, Side effects and safety and Equity (APEASE) criteria were used to design an implementation science-based strategy specific to the critical care context.

Results Survey responses (692) resulted in 16 belief statements and 9 themes with 9 relevant TDF domains. Differences in responses between clinician professional group and hospital setting were common. Based on intervention functions linked to each belief statement and its relevant TDF domain, 26 candidate BCTs were identified and evaluated using APEASE criteria. 23 BCTs were selected and grouped to form 8 key components of a final strategy: Audit and feedback, education, training, clinical decision support, site champions, reminders, implementation support and empowerment. The final strategy was described using the template for intervention description and replication framework.

Conclusions Barriers to a best practice care pathway were identified and were amenable to the design of an implementation science-based mitigation strategy. Future work will evaluate the ability of this strategy to improve

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Use of implementation science to design strategies that mitigate clinician and setting specific barriers can maximise the likelihood of successful adoption of care pathways.
- ⇒ Implementation science-based strategies for improving adoption of hypoxaemic respiratory failure (HRF) and acute respiratory distress syndrome (ARDS) care pathways currently do not exist.

WHAT THIS STUDY ADDS

- ⇒ Describes unique barriers that exist in the critical care setting that prevent adoption and adherence of best practice care pathways.
- ⇒ Describes an implementation science-based strategy to mitigate these barriers in order to improve the quality of care for patients with HRF and ARDS through adoption and adherence to a care pathway.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ This can be used to increase adherence to evidence-based care and improve the quality of patient care.

quality of care by assessing clinician behaviour change via better adherence to evidence-based care.

BACKGROUND

Hypoxaemic respiratory failure (HRF) and its most severe subtype, acute respiratory distress syndrome (ARDS), are common reasons for admission to the intensive care unit (ICU) and are associated with significant attributable mortality.¹⁻³ Several treatments for ARDS have demonstrated survival benefits, including lung protective ventilation and prone positioning.⁴⁻⁹ Despite primary evidence and guidelines endorsing the use of these therapies, substantial variability in their clinical application remains.¹⁰⁻¹² The Institute of Medicine recommends standardised care processes to improve the quality, reliability and safety of care being provided

to patients.¹³ Standardised management with pathways, protocols and bundles improves healthcare quality, reduces practice variation, increases adherence to evidence-informed therapies as well as increases survival for patients with HRF and ARDS.^{14–17}

The mere presence of guidelines alone does not guarantee their uptake and improved quality of care.^{18–21} Effectiveness of any intervention (whether an individual treatment or a bundled pathway) relies on the clinical efficacy of the underlying treatment(s) in addition to a successful implementation strategy. Unfortunately, implementation of evidence-informed best practice is challenging.^{22–23} There is a clear need to develop strategies to support the adherence to best clinical practice. The American Thoracic Society has put out a call to increase the use of implementation science in critical care.²⁴ Knowledge translation experts have identified the need for theory-informed interventions to change clinical practice.^{18–22–25–29}

The Behaviour Change Wheel (BCW) is a comprehensive model that can be used to design techniques or strategies aimed at changing behaviour.^{25–30} At the core of the BCW are six key drivers of behaviour: psychological capability, physical capability, social opportunity, physical opportunity, automatic motivation and reflective motivation.^{25–30} The components of *capability, opportunity, and motivation - behaviour (COM-B)* are tools to understand barriers for a target behaviour to occur.^{25–31} They expand into 14 domains of the Theoretical Domains Framework (TDF). The TDF was developed to understand behaviours of healthcare professionals to inform the implementation of evidence-based care.^{26–32} The TDF domains in turn map to nine intervention functions which describe the way that an intervention changes behaviour (online supplemental eFigure 1, eTable 1). A comprehensive implementation science-based approach to care pathway implementation has not been attempted in critical care for HRF and ARDS.

We have previously developed and validated an evidence-based, stakeholder-informed care pathway for patients with HRF and ARDS.³³ The objectives of this study are to: (1) identify barriers and facilitators to implementation of an HRF and ARDS pathway using the TDF and the BCW, (2) identify possible implementation techniques using behaviour change technique (BCT) taxonomy and (3) develop and rigorously describe a theory-based implementation strategy for the HRF/ARDS pathway that is appropriate for the critical care setting.

METHODS

Target behaviour

The target behaviour is adherence to a multidisciplinary, evidence-based, stakeholder-informed, integrated care pathway for HRF and ARDS.

Definitions, theories, models and frameworks

The *Behaviour Change Wheel (BCW)* is a comprehensive model developed from 19 frameworks of behaviour change used to design interventions.^{25–30} (figure 1)

Capability, opportunity and motivation - behaviour (COM-B) are six overarching areas within the BCW that represent drivers of a target behaviour.^{25–31}

The *Theoretical Domains Framework (TDF)* is comprised of 14 domains that expand the 6 central COM-B areas to further delineate factors that influence the target behaviour.^{26–32} The factors may be either a barrier or facilitator depending on their presence or absence.

Intervention functions comprise nine strategies that may be used to change behaviour. Specific *COM-B* and *TDF* domains link to specific *intervention functions*.

Behaviour change techniques (BCTs, classified in the behaviour change taxonomy V.1) are a standardised taxonomy of 93 active intervention components defined as the smallest, replicable components of behaviour change interventions that can operationalise intervention functions.^{25–34–36}

The Affordability, Practicality, Effectiveness and cost-effectiveness, Acceptability, Side effects and safety and Equity (APEASE) criteria is a framework to assess which *BCTs* are most appropriate for the context in which they are being considered.²⁵

The *template for intervention description and replication (TIDieR)* guide informs the reporting of interventions to improve reproducibility.³⁷

Study design

A survey questionnaire was conducted to assess content validation as well as explore barriers and facilitators to an evidence-based pathway to manage HRF and ARDS. The survey contained two components. The first part was a quantitative assessment to validate agreement with each element of the pathway and has previously been reported.³³ The second part was a qualitative assessment with a total of 12 open text sections in which clinicians were given opportunity to comment on each pathway treatment (*see online supplemental eText 1 for open text survey questions*). This study explores the open text responses from the qualitative part of the survey. We chose to conduct a survey rather than interviews because our goal was to efficiently collect a breadth of perspectives from a diversity of providers and ICU types. This qualitative study used deductive analysis to code open text responses into the 14 TDF domains followed by the generation of belief statements and themes inductively within and across TDF domains as previously described.^{26–38–40}

Participants

The survey was administered by email to all clinicians (critical care physicians (MDs), registered respiratory therapists (RTs), nurse practitioners (NPs) and registered nurses (RNs) in all 17 adult medical-surgical ICUs across Alberta between 13 March 2018 and 9 May 2018 using an online platform (SurveyMonkey). In total, the survey was

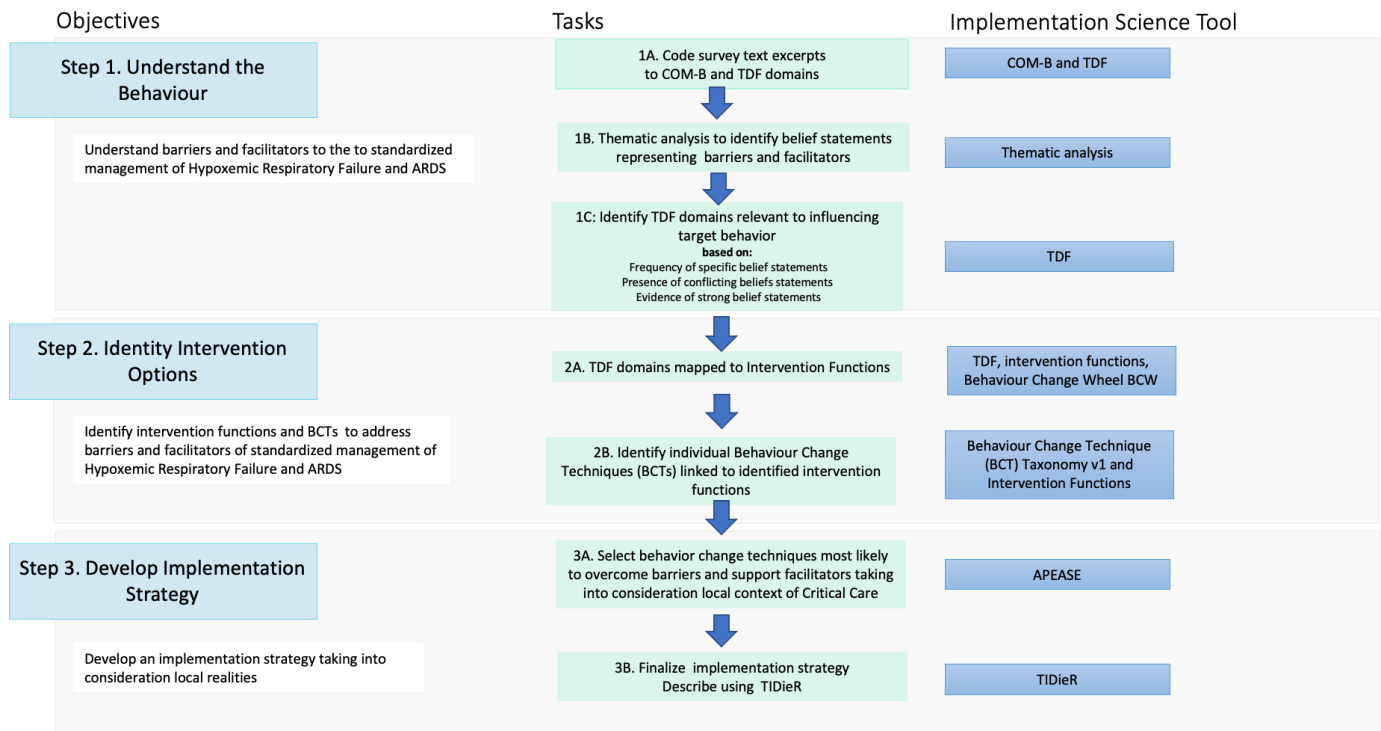


Figure 1 Study methods. A detailed description of the three step method to develop an implementation strategy. APEASE, Affordability, Practicality, Effectiveness and cost-effectiveness, Acceptability, Side effects, Equity; ARDS, acute respiratory distress syndrome; BCT, behaviour change technique; BCW, Behaviour Change Wheel; COM-B, capability, opportunity, motivation - behaviour; TDF, Theoretical Domains Framework; TIDieR, template for intervention description and replication.

sent to 3505 clinicians (2287 RNs, 806 RTs and 412 MDs). The survey was piloted with a multidisciplinary group of study investigators for clarity, length and completeness. Four survey reminders by email were sent.

Analysis

The process to analyse and develop an implementation strategy is summarised in figure 1. It involved qualitative analysis of the survey data (Step 1A/B/C) and creation of an ICU specific implementation strategy (Step 2A/B and Step 3A/B) as previously described.^{25 26}

Step 1A – coding survey data into COM-B and TDF domains to identify barriers

A coding guideline was developed, with a priori categories based on the six major COM-B areas, the associated 14 TDF domains and also included domain descriptions and example statements (see online supplemental eTable 2 for the coding guideline). This guideline was iteratively refined by coding a minimum of three responses in parallel (GEK, KKSP) as previously described.^{26 41 42} Using a directed content analysis approach to deductively code the data,³⁹ any survey responses deemed potentially relevant to influencing pathway implementation were assigned to one or more TDF and COM-B domains (GEK). Inter-rater reliability was assessed by double coding 10% of responses (KKSP, GEK) and calculating a Cohen's kappa to ensure coding was sufficiently reliable (Kappa >0.7). Discrepancies were discussed and resolved.⁴³

Step 1B – thematic analysis

Belief statements and overarching themes were generated inductively from the coded responses from Step 1A (Step 1B).^{32 44} The researchers independently reviewed each response within a domain and performed line-by-line inductive coding.³⁸ Researchers met to review emerging findings; differences were resolved with discussion. Belief statements which summarise a group of responses with similar underlying beliefs representing barriers or influences on the target behaviour⁴⁴ were identified. Overarching themes that capture the essence of a group of related belief statements were generated within and across domains.³⁸ The total number of survey excerpts assigned (and its corresponding survey question) to each belief statement was quantified.

Step 1C – identify TDF domains likely to influence target behaviour

To identify TDF domains most likely to influence the target behaviour, each domain was assessed for importance based on (1) frequency of belief statement, (2) presence of conflicting beliefs and (3) evidence of strong beliefs likely to influence target behaviour as previously described.^{26 31 44-46}

Step 2A – identify interventions to change target behaviour

Intervention functions that target the TDF domains from the identified themes and beliefs were summarised (online supplemental eFigure 1 and eTable 1) as

previously described.²⁵ Intervention functions can potentially convert a TDF domain from a barrier to a facilitator.

Step 2B – identify BCTs most frequently linked to identified intervention functions

For identified intervention functions, we identified all potential BCTs from the BCT taxonomy V.1 (online supplemental eTable 3).^{25 47}

Step 3A – identify BCTs for the critical care context

Each candidate identified BCT was assessed using the APEASE criteria to determine whether it was *affordable*, *practical*, *effective*, *acceptable*, *safe* and *equitable* in the critical care setting.²⁵ Two reviewers assessed each BCT and any disagreements in assessment were resolved through discussion.

Step 3B – final implementation strategy

The least number of BCTs that could address the most frequent barriers were included in the final intervention and were deemed the implementation strategy. The components were summarised using TIDieR criteria.³⁷ A working group of ICU clinician leaders (four MDs, two RNs, two RTs) reviewed the BCTs and final implementation strategy to ensure face validity.

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Ethical considerations and reporting

The study was approved by the Conjoint Health Research Ethics Board (University of Calgary, REB 17–1053). This qualitative study follows the Standards for Reporting Qualitative Research reporting guideline.⁴⁸

RESULTS

Participants

266 clinicians responded to survey open text questions (online supplemental eTable 4). Respondents included 115 (43%) RNs, 123 (46%) RTs and 28 (11%) MDs and NPs. Respondents originated from all 17 ICUs in tertiary (49%), community (36%) and regional (15%) hospitals. 786 text responses to the 12 open text questions were received. A total of 628 text excerpts were determined to be relevant to the target behaviour. Cohen's kappa for duplicate coding of the initial 10% responses into TDF domains was 0.85 with a 95% CI of (0.77 to 0.93).

Results by domain

Coded responses represented all six COM-B components; however, only 9 out of 14 TDF domains were represented. Text excerpts were most frequently coded into the following TDF domains: *Beliefs about consequences*, *Knowledge* and *Social influences* (see figure 2; online supplemental eFigure 2). Coded responses could be summarised into 16 belief statements that were relevant to influencing the target behaviour. The belief statements associated with the highest number of text excerpts were barriers to pathway

adoption, *I disagree with a pathway element*, *We rarely perform this pathway element* and *Treat based on patient presentation, not a pathway* (see online supplemental eFigure 3). The same belief statement could be considered a barrier or a facilitator based on its context (eg, lack of knowledge or presence of adequate knowledge). Belief statements were further synthesised into nine overarching themes. Table 1 summarises (1) belief statements and themes, and (2) the frequency of coded responses to TDF and COM-B components. Relevant TDF domains are detailed below.

Beliefs about consequences

The highest number of text excerpts (329/628) and belief statements (5/16) were coded into *Beliefs about consequences*. In this domain there was an overall lack of consensus around evidence-informed practice for patients with HRF and ARDS. This included questioning the evidence supporting a procedure; for example, 'Recent papers suggest recruitment maneuvers increase mortality, how will this factor into our previously widespread use of recruitment maneuvers?'. Disagreement with a specific pathway procedure, intervention, threshold, criteria or timing was identified in the highest number of text excerpts across all 12 questions. For example, an RT from a tertiary centre responded, 'Prone [placing patients in the prone position] is high maintenance and has a high risk of extubation especially when we are not at the bedside. [Prone when the oxygen requirement is] 60% is certainly nowhere near when I would entertain the idea'. Conversely, many respondents agreed with the use of these same elements. In contrast to the above comment about prone, an RN from a community hospital states, 'I believe early prone results in better outcomes for the patients. It is my experience that enacting this early results in shorter time spent prone, ...and overall better and quicker recovery from ARDS'.

Conflicting beliefs were commonly expressed, especially regarding the risks and benefits of sedation with one respondent stating that it is 'Very difficult to meet lung protective strategies when a patient is not adequately sedated. Sometimes when [this is] addressed to RNs or residents no major changes are made to facilitate the strategy' while another expressed that '[The] RASS [Richmond agitation and sedation score to assess patients' level of sedation] goal should be as minimal as possible to avoid oversedation'.

Knowledge

Respondents disclosed a lack of knowledge about certain interventions, procedures and clinical information critical to the pathway. This was common for RNs regarding mechanical ventilation focused pathway elements (eg, understanding the ratio of partial pressure of oxygen in arterial blood [PaO₂] to the fraction of inspiratory oxygen concentration [FiO₂] [PaO₂/FiO₂, PF ratio], measuring plateau pressures); for example, an RN states, 'No clinical education of PF [ratio] criteria has been provided in our ICU'. Knowledge deficits were also identified within

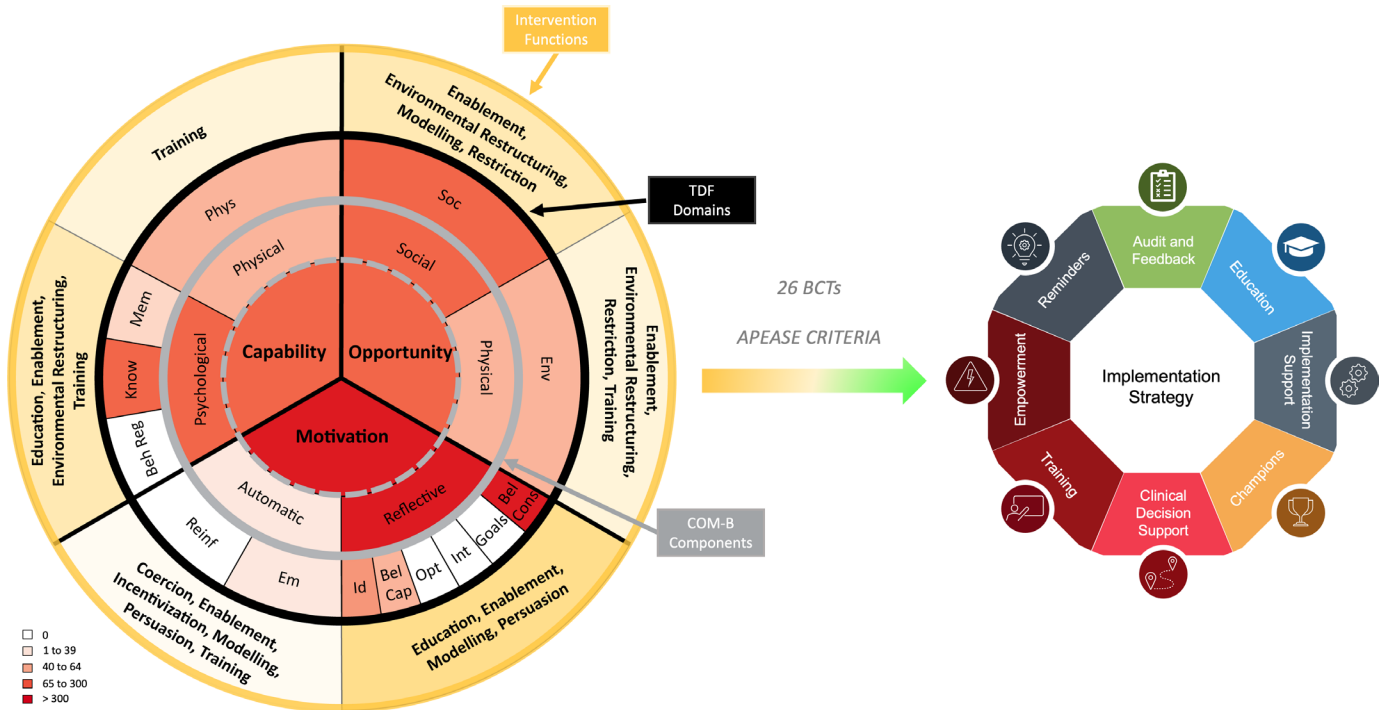


Figure 2 Barriers to evidence-based management of hypoxaemic respiratory failure and ARDS by the COM-B component and TDF domains with corresponding intervention functions and final implementation strategy. In the first three rings of the Behaviour Change Wheel (left), shading corresponds to the number of text excerpts coded into that domain that represented barriers to implementation of an HRF and ARDS pathway. APEASE Affordability, Practicality, Effectiveness and cost-effectiveness, Acceptability, Side effects, Equity; ARDS, acute respiratory distress syndrome; BCTs, behaviour change techniques; Beh Reg, behavioural regulation; Bel Cap, beliefs about capabilities; Bel Cons, beliefs about consequences; COM-B, capability, opportunity motivation - behaviour; Em, emotion; Env, environmental context and resources; Goals, goals; HRF, hypoxaemic respiratory failure; Id, social/professional identity; Int, intentions; Know, knowledge; Mem, memory, attention and decision processes; Opt, optimism; Phys, physical skills; Reinf, reinforcement; Soc, social influences; TDF, Theoretical Domains Framework.

clinicians' scope of practice; for example, an RT asked 'What do you mean by driving pressure? Clearly define more'.

Social influences

Respondents expressed that a wide range of pathway elements were not widely accepted in their ICU due to social norms at a site level; for example, an RT from a regional site shared 'We do not tend to use neuromuscular blockade with any of our patients'.

Social/professional role and identity

A reluctance to expand traditional professional roles and concerns about scope of practice were common as illustrated by an RT from a tertiary centre who states, '[I am] not responsible for performing neuromuscular blockade'.

Environmental context and resources

The most common responses in this domain reflect a lack of access to resources or technology required to implement pathway elements or sufficient staffing to perform them; for example, '[We will] Need to look at unit staff availability if these decisions [for proning] are being made in the middle of the night'.

Physical skills

Across all hospital settings, respondents reported a skills deficit for prone positioning ('I feel our unit team would benefit from a thorough proning inservices by well informed, experienced / current individuals. '), optimal positive end expiratory pressure (PEEP) studies ('Clarity on the PEEP study technique is needed. I'm not confident in our current practice and it seems inconsistent') and the use of oesophageal balloons ('RTs need to be trained appropriately for use of the esophageal balloon. ').

Beliefs about capabilities

Some respondents perceived that a pathway intervention was not possible within the suggested time frames or were not confident they could perform it: 'A proper PEEP study takes a long time to do. [Performing this every] 4H [hours] might not be possible'.

Memory, attention and decision-making

Conflicting beliefs about standardised management were identified. Some strongly expressed that HRF and ARDS management should be based on clinician judgement rather than standardised management, 'Anyone can run numbers and follow 'recipe' protocols, treating sick

Table 1 Understanding the behaviour: Relevant TDF domains and COM-B components with generated belief statements and themes

Survey text responses coded and mapped TDF domains and COM-B components		Thematic analysis*		Relevant domains		
Sample quotes from survey text responses	TDF domain	COM-B	Belief statement	Freq [†] /12 [‡]	Theme	Criteria [§]
'6–8 mL/kg is too high for current lung protective strategies.' – RT, T, 4. 'Once again, I have worked many years and at many institutions and have had successful treatments without PEEP studies!' – RT, C, 6. 'RASS should be –1' – RN, R, 9. 'Very helpful to have all these interventions for such critically ill pts.' – RN, T, 1. 'No comment, just agree with all of the above [screening].' – RT, R, 3. 'My site only uses proning as a last ditch effort so if done earlier may be more effective so I agree with this criteria.' – RT, C, 11. 'Limited evidence so far on the esophageal balloon.' – RN, T, 7. 'Recent papers suggest recruitment maneuvers increase mortality, how will this factor into our previously widespread use of recruitment maneuvers?' – RT, T, 8. 'Ongoing large RCT reassessing this practice [neuromuscular blockade], so this part of the protocol might need to change pending those results.' – MD, C, 10. 'Very difficult to meet lung protective strategies when pt. not adequately sedated. Sometimes when addressed to RNs or residents no major changes are made to facilitate the strategy.' – RT, T, 9. 'When a pt. is designated as ARDS, sedation should be a high priority. Too often I see refusal from the physicians to sedate pts with dysynchrony on the ventilator because they are still meeting target SpO ₂ ranges/minute volumes. They say they are afraid of oversedating and of increasing delirium but it's horrible to watch someone struggle on the vent.' – RN, C, 9. 'RASS goal should be as minimal as possible to avoid oversedation.' – MD, C, 9. 'Look into delirium work keep your pts. comfortable with minimal sedation.' – RT, C, 9. 'We want to keep in mind delirium and not over sedate our pts.' – RN, T, 9.	Beliefs about consequences (293)	Reflective motivation	Disagree with a pathway element (procedure, intervention, threshold, criteria or timing). Agree with this pathway intervention, it would be beneficial.	151 77	12 12	Frequency Conflicting Strong Frequency Conflicting
			Intervention is/might not be supported by evidence; I am not sure about the accuracy and reliability of this intervention.	30	7	Frequency
			This pathway intervention requires adequate sedation of pts and often they are not.	24	4	Risks vs benefits of sedation Conflicting
			Do not over sedate the pt.	11	1	Conflicting

Continued

Table 1 Continued

Survey text responses coded and mapped TDF domains and COM-B components		Thematic analysis*		Relevant domains		
Sample quotes from survey text responses	TDF domain	COM-B	Belief statement	Freq [†] /12 [‡]	Theme	Criteria [§]
'Not responsible for performing neuromuscular blockade.'- RT, C, 1. 'Respiratory interventions administered by respiratory therapists, not myself.'-RN, C, 1. 'Optimal PEEP Studies] should be on the direction of MD.'- RN, C, 6.	Social/professional role and identity (41) [¶]	Reflective motivation	Reluctance to expand traditional professional roles; stay in your lane.	36	Rigidly defined prof role vs empower and support	Frequency
'Esophageal balloon monitoring has not been widely accepted by the doctors, therefore is rarely seen.'- RT, T, 1. 'PEEP study is widely variant depending on ...MD preferences.'- RT, C, 6.			Pathway intervention not adopted by MDs so not being done.	5		Strong
'RT should determine appropriateness in measuring and complet(ing) (plateau pressure).'- NP, C, 5. 'Rarely within the hour [documenting height and PBW]. Usually within the first 6 hours.'- RN, C, 2. 'A proper PEEP study takes a long time to do. 4H might not be possible.'- RT, T, 6.	Beliefs about capabilities (20) [¶]	Reflective motivation	Not confident we can do this element of the pathway, especially within this time frame.	20	Perception that it is not possible	Strong
'I feel our unit team would benefit from a thorough proning inservice by well informed, experienced / current individuals.'- RT, R, 1. 'Clarity on the PEEP study technique is needed. I'm not confident in our current practice and it seems to be inconsistent.'- RT, T, 6. 'RTs need to be trained appropriately for use of the esophageal balloon.'- RT, T, 7.	Physical skills (22) [¶]	Physical capability	We do not have the skills to perform this pathway intervention; training is needed (proning, oesophageal balloon, PEEP study).	22	Skills deficit: Proning, PEEP study, oesophageal balloon	Strong
'Budget constraints removed [oesophageal balloon] monitoring from our site.'- RT, R, 7. 'Multidisciplinary rounds are not completed on our unit.'- RN, R, 3. 'Not all ICUs have RT at night or during the day for every pt on rounds.'- RN, R, 3. 'Need to look at unit staff availability if these decisions are being made in the middle of the night.'- RN, T, 11.	Environmental context and resources (21) [¶]	Physical opportunity	No access to pathway intervention. Human resource are not available to perform the pathway intervention.	12	Access to interventions and staff	Strong

Continued

Table 1 Continued

Survey text responses coded and mapped TDF domains and COM-B components		Thematic analysis*		Relevant domains		
Sample quotes from survey text responses	TDF domain	COM-B	Belief statement	Freq† /12‡	Theme	Criteria§
<p>*Thematic analysis of coded data to identify belief statements and themes representing barriers and facilitators to pathway implementation.</p> <p>†The number of survey response text excerpts that were generated into the belief statement in the column to the left.</p> <p>‡The number of questions where at least 1 text excerpt (response) was coded to this belief statement out of 12.</p> <p>§The criteria to determine which TDF domains are most likely to influence target behaviour are (1) high frequency of belief statements (total and by question), (2) presence of conflicting beliefs and (3) evidence of strong beliefs likely to influence behaviour.</p> <p>¶The number of survey response text excerpts coded to this Theoretical Domain Framework (TDF) domain representing these belief statements. Following the sample quotes the number=the survey question the excerpt was from.</p> <p>ARDS, acute respiratory distress syndrome; C, community hospital; COM-B, capability, opportunity, motivation - behaviour; HRF, hypoxaemic respiratory failure; LPV, lung protective ventilation; MD, physician; PBW, predicted body weight; PEEP, positive end expiratory pressure; PF, PaO2/FiO2; Pt, patient; R, regional hospital; RN, registered nurse; RT, respiratory therapist; Soc, social; T, tertiary hospital; TDF, Theoretical Domains Framework.</p>						

patients requires skilled and experienced staff who can make decisions based on patient condition rather than an arbitrary 'Big Brother' protocol'. Conversely others suggested the need for a protocol or guideline particularly for each element within the pathway. One example illustrating this comes from an RN at a regional hospital who asked, 'I have never heard of screening [for HRF and ARDS] be discussed on rounds. I feel this would be a very useful tool but it will require education for RNs'.

Emotion

Feelings were expressed against the use of standardised management including regular screening: 'We did ALI [acute lung injury / ARDS] screening every 24 hours a few years ago that were found to be **annoying** as all it did was prove over and over what you already knew. I was not a fan'. The belief statement that patient care should be based on clinical presentation and not a threshold in a pathway was common and identified from text excerpts coded into four distinct TDF domains. For more details on results by domain please see [table 1](#), online supplemental eFigure 3 and 4.

Belief statements and TDF domains by discipline

The belief statement that was most commonly identified from physicians' text excerpts was disagreement with a pathway element including the utility of the pathway in general, 'My population has a low rate of ARDS and screening would identify very few such cases'. Physicians also commonly expressed the belief that some pathway elements, especially neuromuscular blockade and recruitment manoeuvres, were not supported by evidence 'Recruitment maneuvers [have] never shown to benefit patients, and in fact, a recent RCT [study] showed association with increased mortality. [They] should be reserved for research study only, or as directed by MD when all else failing'. Physicians also expressed agreement with pathway elements; for example, '[Placing patients in the prone position should be our first line of treatment. Earlier is better'. Physician text responses were coded most frequently to the TDF domains *Beliefs about consequences* and *Knowledge*. One physician from a tertiary centre writes, 'Confession: I am personally unclear exactly how to use BOTH these pieces of data [height and predicted body weight] for optimal tidal volume'.

The belief statement that was most commonly identified in RN text excerpts was a lack of knowledge or understanding about a pathway intervention especially regarding elements not typical of their scope of practice. RNs also commonly expressed that their unit did not perform a pathway element due to social norms, 'Rarely do we prone'. RN responses were coded most frequently to the TDF domains *Knowledge*, *Beliefs about consequences* and *Social influences*. The belief statement most frequently identified in RT text responses was disagreement with a pathway element; for example, '[A ventilation volume of] 6–8 [ml/kg predicted body weight] is too high for current lung protective strategies' followed by agreement with

a pathway element, 'No comment, just agree with all of the above [screening patients for HRF and ARDS]'. RTs also strongly expressed the belief that treatment should be based on clinical presentation rather than a pathway. RT responses were coded most frequently to the TDF domains *Beliefs about consequences*, *Social influences* and *Social/professional role and identity*. The barrier belief statements that were assigned the largest number of excerpts are summarised in online supplemental eTable 5,6 and eFigure 5. The TDF domains coded with the highest number of survey text excerpts representing a barrier are summarised in online supplemental eFigure 6 and eTable 7.

Belief statements and TDF domains by hospital type

The belief statement identified most frequently in text excerpts from clinicians at regional hospitals was that treatment should be based on clinical presentation, not a pathway. As an RT from a regional hospital states, 'Rescreening should depend on clinical state not automatically at scheduled intervals'. Clinicians from regional ICUs also commonly expressed disagreement with, as well as a lack of knowledge about, a pathway element. Community and tertiary centres shared the most common belief statements: *Disagreement with a pathway element*, expressing that they *rarely perform a pathway element on their unit* and the belief that *treatment should be based on clinical presentation, not a pathway*.

Barriers from regional, community and tertiary ICU were most frequently coded into *Beliefs about consequences*, *Knowledge* and *Social influences*; however, tertiary ICUs expressed fewer *Knowledge* and more *Social influences* barriers. The barrier belief statements that were assigned the largest number of excerpts are summarised in and online supplemental eTable 5,8 and eFigure 7. The TDF domains coded with the highest number of survey text excerpts representing a barrier are summarised in online supplemental eFigure 8 and eTable 9.

Intervention function mapping

The six COM-B components and nine relevant TDF domains from the belief statements and themes mapped to all nine intervention functions. Each intervention function could be used to target multiple barriers; for example, 11 belief statements that were identified as barriers were addressed by the intervention function, *Education*.

The nine interventions functions link to 26 'candidate' BCTs (see table 2; online supplemental eTable 3 and 10 for details). Intervention functions linked to the highest number of belief statements which were also barriers to pathway implementation are *Enablement*, *Education*, *Modelling*, *Persuasion* and *Environmental restructuring*. The BCTs that were linked to the most common belief statements were *feedback on behaviour* and the *outcomes of behaviour*, *prompts/cues*, *information about health consequences*, *self-monitoring of behaviour* and *adding objects to or restructuring the physical environment*. Online supplemental eFigure

4 depicts the relationship between the COM-B components, TDF domains, themes and belief statements.

The 26 candidate BCT interventions were evaluated using the APEASE criteria. Only 23 were determined to be affordable, practical, effective, acceptable, safe and equitable in the critical care setting (online supplemental eTable 10). These 23 BCT interventions were further consolidated into eight key strategies: (1) Audit and feedback; (2) education; (3) training; (4) clinical decision support; (5) site champions; (6) reminders; (7) implementation support; and (8) empowerment. Table 3 details the belief statements, themes, candidate BCT interventions reported according to the TiDiEr and APEASE criteria. Figure 2 represents the results mapped to the BCW and the final implementation strategy.

DISCUSSION

In this study we use the BCW and TDF to identify barriers that prevent the target behaviour of using a multidisciplinary evidence informed pathway of care for patients with HRF and ARDS. These barriers, which included six COM-B components and nine TDF domains, allowed us to identify nine potential intervention functions and 26 behaviour change techniques. The APEASE criteria helped select techniques suitable for the critical care setting. Barriers differed according to hospital type and according to clinician group. The most frequently identified barriers were: (1) *Beliefs about consequences*, (2) lack of *knowledge* critical to performance, (3) *Social influences* and (4) conflicting beliefs about standardised management (*memory, attention and decision processes, emotion, beliefs about capability*). A final implementation strategy was summarised as having eight key components: (1) Audit and feedback; (2) education; (3) clinical decision support; (4) reminders; (5) training; (6) site champions; (7) implementation support; and (8) empowerment. We describe the strategy using the TiDiEr criteria, to enable future reproducibility. Future work will focus on demonstrating if this evidence informed strategy can improve the quality of care being delivered.

Although guidelines for the management of ARDS exist, challenges with improving the real-world quality of care still exist. Practical implementation science-based strategies that target sustained adoption of guideline-based recommendations are lacking. This gap is highlighted by an American Thoracic Society's call for more implementation science in the field of critical care.²⁴ Our report is the first to use implementation science to identify barriers and develop a comprehensive implementation strategy for an entire ICU care pathway. A previous scoping review on barriers and strategies in guideline implementation did not find any critical care specific studies.²⁰ Previous studies have examined barriers to the ABCDE delirium bundle,⁴⁹ individual ARDS management components,^{44 50-54} appropriate transfusion and early mobilisation^{26 50} but did not address barriers to large

Table 2 Identify intervention options: COM-B components and TDF domains mapped to intervention functions and behaviour change techniques

Theme and belief statement	TDF and COM-B deemed relevant	Identified intervention functions	Candidate behaviour change techniques (BCTs)
<p>*Lack of knowledge about pathway elements</p> <ul style="list-style-type: none"> Do not know a pathway intervention/have the education to perform the pathway. Unclear on definition and importance of height and predicted body weight for lung protective ventilation. 	<p>Knowledge</p> <p>Psychological capability</p>	<p>Education</p>	<p>2.2 Feedback on behaviour</p> <p>2.3 Self-monitoring of behaviour</p> <p>2.7 Feedback on outcomes of the behaviour</p> <p>5.1 Information about health consequences</p> <p>5.2 Saliency of consequences</p> <p>5.3 Information about social and environmental consequences</p> <p>7.1 Prompts/cues</p> <p>9.1 Credible source</p>
<p>*Conflicting feelings and beliefs about standardised management</p> <ul style="list-style-type: none"> Treat based on individual patient presentation, NOT a threshold in pathway. Patient presentation and clinical judgement trumps standardised management. 	<p>Memory, attention and decision processes^a</p> <p>Psychological capability</p>	<p>Training^a</p>	<p>2.2 Feedback on the Behaviour</p> <p>2.3 Self-monitoring of behaviour</p> <p>2.7 Feedback on the outcomes of the behaviour</p> <p>4.1 Instruction on how to perform a behaviour</p> <p>6.1 Demonstration of the behaviour</p> <p>8.1 Behavioural practice/rehearsal</p>
	<p>Emotion^b</p> <p>Automatic motivation</p>	<p>Environmental restructuring^a</p>	<p>7.1 Prompts/cues</p> <p>12.1 Restructuring the physical environment</p> <p>12.2 Restructuring the social environment</p> <p>12.5 Adding objects to the environment</p>
	<p>Beliefs about capabilities^c</p> <p>Reflective motivation</p>	<p>Enablement^{a,b,c}</p>	<p>1.1 Goals setting (behaviour)</p> <p>1.2 Problem solving</p> <p>1.3 Goal setting (outcome)</p> <p>1.4 Action planning</p> <p>2.3 Self-monitoring of behaviour</p> <p>3.1 Social support (unspecified)</p> <p>3.2 Social support (practical)</p> <p>11.5 Review of behaviour goals</p> <p>11.7 Review outcome goals</p> <p>12.1 Restructuring of the physical environment</p> <p>12.2 Restructuring the social environment</p> <p>12.5 Adding objects to the environment</p>
	<p>Beliefs about consequences^d</p> <p>Reflective motivation</p>	<p>Incentivisation^b</p>	<p>2.1 Monitoring of behaviour by others without feedback</p> <p>2.2 Feedback on behaviour</p> <p>2.3 Self-monitoring of behaviour</p> <p>2.5 Monitoring the outcome(s) of behaviour without feedback</p> <p>2.7 Feedback on outcomes of the behaviour</p> <p>5.1 Information about health consequences</p> <p>10.2 Material reward</p>

Continued

Table 2 Continued

Theme and belief statement	TDF and COM-B deemed relevant	Identified intervention functions	Candidate behaviour change techniques (BCTs)
		Coercion ^b	2.1 Monitoring of behaviour by others without feedback 2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 2.5 Monitoring the outcome(s) of behaviour without feedback 2.7 Feedback on outcomes of the behaviour
		Education ^{c,d}	See <i>Education</i> BCTs listed above
		Persuasion ^{b,c,d}	2.2 Feedback on behaviour 2.7 Feedback on outcomes of the behaviour 5.1 Information about health consequences 5.3 Information about social and environmental consequences 6.2 Social comparison/reminder of past success 9.1 Credible source
		Modeling ^{b,c,d}	6.1 Demonstration of the behaviour
*Conflicting feelings and beliefs about standardised management A guideline or protocol for this pathway intervention is needed.	Memory, attention and decision processes ^a Psychological capability	Training Environmental restructuring	See <i>Training</i> BCTs listed above See <i>Environmental restructuring</i> BCTs listed above
	Physical skills Physical capability	Enablement Training	See <i>Enablement</i> BCTs listed above See <i>Training</i> BCTs listed above
Skills deficit: Prone positioning, optimal PEEP study, oesophageal balloons We do not have the skills to perform a pathway intervention (oesophageal balloon, optimal PEEP study).	Social influences Social Opportunity	Environmental restructuring Modelling Enablement Restriction	See <i>Environmental restructuring</i> BCTs listed above See <i>Modelling</i> BCTs listed above See <i>Enablement</i> BCTs listed above No BCTs
*Pathway intervention is not widely accepted due to social norms at a site level We rarely or never perform this pathway element at my site.	Environmental context and resources Physical opportunity	Training	See <i>Training</i> BCTs listed above
Lack of access to interventions and staffing levels <ul style="list-style-type: none"> ▶ No access to a pathway intervention at my site. ▶ Human resources not available to perform the pathway. 	Enablement Restriction	See <i>Enablement</i> BCTs listed above No BCTs	

Continued

Table 2 Continued

Theme and belief statement	TDF and COM-B deemed relevant	Identified intervention functions	Candidate behaviour change techniques (BCTs)
Rigidly defined professional roles vs empowerment and support <ul style="list-style-type: none"> ▲ Reluctance to expand traditional professional roles; stay in your lane. ▲ This pathway intervention has not been adopted by MDs so it is not being done. 	Social/professional role and identity Reflective Motivation	Education Persuasion Modelling	See Education BCTs listed above See Persuasion BCTs listed above See Modelling BCTs listed above
Perception that it is not possible Not confident we can do this element of the pathway, especially within this time frame.	Beliefs about Capabilities Reflective motivation	Education Persuasion Modelling	See Education BCTs listed above See Persuasion BCTs listed above See Modelling BCTs listed above
*Lack of consensus on HRF/ARDS evidence-informed practice <ul style="list-style-type: none"> ▲ Disagree with a pathway procedure, intervention, threshold, criteria or timing. ▲ Agree with this intervention on the pathway, it would be beneficial. ▲ Is not or might not be supported by evidence. *Risks vs benefits of sedation <ul style="list-style-type: none"> ▲ Can only perform this pathway intervention if patients are adequately sedated, and often they are not. ▲ Do not over sedate the patient. 	Beliefs about Consequences Reflective motivation	Enablement Education Persuasion Modelling	See Enablement BCTs listed above See Education BCTs listed above See Persuasion BCTs listed above See Modelling BCTs listed above
<p>Listed belief statements and TDF domains were judged relevant to influence target behaviours for pathway implementation. Rows with an asterisk* are considered especially important to address because they represent barriers with the highest frequency of text excerpts. Excerpts grouped into the theme <i>Conflicting feelings and beliefs about standardised management</i> were coded into four TDF domains as listed in column 2: <i>a=Memory, attention, and decision processes</i>, <i>b=Emotion</i>, <i>c=Beliefs about capabilities</i>, <i>d=Beliefs about consequences</i>. In column 3, the interventions that were linked to these four TDF domains are noted with letters; for example, the intervention function, <i>Persuasion</i>, is linked to the TDF domains <i>b=Emotion</i>, <i>c=Beliefs about capabilities</i>, <i>d=Beliefs about consequences</i>. Candidate BCTs listed in the final appropriate for the listed intervention function, bolded BCTs are frequently used for the corresponding intervention function.²⁵ BCT numbers, for example, <i>2.2 Feedback on the behaviour</i>, are from the BCT taxonomy V.1.³⁴</p> <p>ARDS, acute respiratory distress syndrome; COM-B, capability, opportunity, motivation - behaviour; HRF, hypoxaemic respiratory failure; MD, physician; PEEP, positive end expiratory pressure; TDF, Theoretical Domains Framework.</p>			

Table 3 Develop implementation strategy: Selected intervention functions and behaviour change techniques reported using TIDieR guideline and evaluated with APEASE criteria

TIDieR						
Themes and belief statements	Selected intervention functions	Selected behaviour change techniques (BCTs)	Brief description of BCT intervention	Rationale (why)	Delivery (By and To whom, How, How well)	Key strategy
<p>*Lack of knowledge about pathway elements</p> <p>Do not know a pathway intervention.</p> <p>Do not know importance of height and PBW for LPV.</p>	Education.	<p>2.3 Self-monitoring of behaviour.</p> <p>2.7 Feedback on outcomes of the behaviour.</p> <p>5.1 Information about health consequences.</p> <p>5.2 Salience of consequences.</p> <p>9.1 Credible source.</p>	<p>2.3 Provide self-guided learning modules, education binders, laminated learning aids.</p> <p>2.7 Share pathway outcomes including from similar sites.</p> <p>5.1 Introductory education sessions, ongoing inservices and interactive rounds include knowledge and evidence for pathway.</p> <p>5.2 Education sessions include consequences for patients with ARDS.</p> <p>9.1 Respected pathway champions provide education.</p>	<p>Sustained understanding of pathway elements is required, therefore introduce, educate, generate enthusiasm among staff about the pathway and provide background regarding pathway interventions.</p>	<p>By: KT PLs, PI, site champions</p> <p>To: Clinicians (RN, RT, MDs) managing patients on the pathway. How: In-person sessions to initiate champions. Ongoing ad hoc sessions. How well: Knowledge assessment surveys.</p>	Education, champions.
<p>*Conflicting feelings and beliefs about standardised management (SM)</p> <p>Disagree with SMI</p>	<p>Incentivisation, education, persuasion.</p>	<p>2.7 Feedback on the outcomes of the behaviour.</p> <p>5.1 Information about health consequences.</p> <p>9.1 Credible source.</p> <p>10.2 Material reward.</p>	<p>2.7 Demonstrate that outcomes improve with SM while acknowledging clinical judgement is key and synergistic with the pathway.</p> <p>5.1 Provide evidence for pathway elements.</p> <p>9.1 Respected champions relay information about evidence and outcomes.</p> <p>10.2 Small acknowledgement prize for improved compliance.</p>	<p>Rationale for SM can increase acceptance of SM. Messages (1) rationale for SM (2) clinical judgement AND SM should lead to the best outcomes, (3) the pathway supports clinical expertise and creativity.</p>	<p>By: KT PLs, PI, site champions.</p> <p>To: Clinicians managing patients on the pathway. How: In-person and virtual. Adherence rates and targets displayed as posters in the unit.</p> <p>How often: Baseline feedback at initiation, approximately 6 weeks post implementation and monthly thereafter.</p> <p>How well: Fidelity measurement of KPIs, focus groups.</p>	<p>Audit and feedback, education, champions.</p>
<p>A guideline or protocol for this pathway intervention is needed.</p>	<p>Training, environmental restructuring, enablement.</p>	<p>2.3 Self-monitoring of behaviour.</p> <p>4.1 Instruction on how to perform a behaviour.</p> <p>12.5 Adding objects to the environment.</p>	<p>2.3 Provide checklists for individual pathway interventions as required.</p> <p>4.1 Provide practice guidelines for all pathway elements for sites to refine to their context.</p> <p>12.5 Policies, checklists and reminders are accessible to staff on unit.</p>	<p>Sustained empowerment of clinicians to perform interventions and suggest management options is key. Guidelines/checklists encourage self-monitoring and empower RTs/RNs.</p>	<p>By: KT PLs, PI, site champions.</p> <p>To: Clinicians managing patients on the pathway. How: Checklists and practice guidelines are discussed and emailed as required. How often: At initiation and implementation support, champions, empowerment.</p>	<p>Training, reminders, clinical decision support, implementation support, champions, empowerment.</p>
<p>Skills deficit</p> <p>We do not have the skills to perform this intervention; training is needed.</p>	<p>Training.</p>	<p>4.1 Instruction on how to perform a behaviour.</p> <p>6.1 Demonstration of the behaviour.</p> <p>8.1 Behavioural practice/rehearsal.</p> <p>9.1 Credible source.</p>	<p>4.1 Provide education, simulations, guidelines, videos for challenging pathway interventions.</p> <p>6.1 Training inservices.</p> <p>8.1 Simulations of interventions are available; repetition with certification is encouraged.</p> <p>9.1 Skilled local champions and KT PL demonstrate skill specific, hands-on training.</p>	<p>Clinicians must have the sustained ability to perform all pathway elements.</p>	<p>By: KT PLs, PI, site champions.</p> <p>To: Clinicians managing patients on the pathway. How: In-person, hands-on skill specific training, video, simulation, certification. How often: Site specific PRN. How well: Survey/focus groups.</p>	<p>Training, champions, implementation support.</p>

Continued

Table 3 Continued

Themes and belief statements		TIDier		Key strategy	
Selected intervention functions	Selected behaviour change techniques (BCTs)	Brief description of BCT intervention	Rationale (why)	Delivery (By and To whom, How, How well)	
<p>*Pathway intervention is not in line with unit norms and practices</p> <p>We rarely or never perform this pathway element at my site</p>	<p>Social support (3.1 Unspecified, 3.2 Practical). 6.1 Demonstration of the behaviour: 7.1 Prompts /cues. 9.1 Credible source. 11.5 Review of behaviour goals. 11.7 Review of outcome goals. 12.1 Restructuring the physical environment. 12.2 Restructuring of the social environment. 12.5 Adding objects to the environment.</p>	<p>3.1 Outreach to staff. 3.2 Site champions educate, train, provide feedback and troubleshooting issues that arise with pathway implementation. Pl and KT PLs support site champions as required. ICUs who have successfully implemented the pathway support and share lessons and expertise with onboarding ICUs. 6.1 Respected champions perform pathway elements. 7.1 Pathway guideline document detail each section of the pathway noting threshold prompts and responsible practitioner. Posters and pocket cards cue interventions. 9.1 Respected champions share successful change strategies. 11.5 and 11.7 Behaviour and outcome goals are suggested and reviewed by champions to encourage performance of pathway. 12.1 CDS built into the CIS empowers all clinicians to discuss goals and suggest interventions at daily rounds. 12.2 Champions, reminders, training and implementation support empower clinicians. 12.5 Direct reminders of posters, laminated pathways and pocket cards.</p>	<p>Pathway to be incorporated into local ICU contexts. Interventions to be embedded into ICU daily practice and RTs and RNs are empowered to perform or suggest pathway management during daily bedside rounds.</p>	<p>By: Champions including at other successfully implemented sites, Pl, KT PLs. To: Clinicians managing patients on the pathway. How: Face-to-face, email, virtual meetings. CDS available on unit and built into the CIS. How often: Site specific, PRN. How well: Focus groups. Fidelity measurement of KPIs will be tracked.</p>	<p>Reminders, clinical decision support, champions, implementation support, empowerment.</p>
<p>Lack of access to interventions and staffing</p> <p>No access to this intervention or HR to perform.</p>	<p>1.2 Problem solving. 3.1 Social support (unspecified). 12.1 Restructuring of the physical environment.</p>	<p>2.1 Champions and KT PLs problem solve staffing/access issues and other physical barriers. 3.1 Champions at successfully implemented sites share ways in which other sites have dealt with similar challenges. 12.1 If the intervention is critical to the pathway, work to see if it can be made available or develop workarounds if it cannot.</p>	<p>ICUs to perform and sustain pathway practices despite resource challenges. Sharing 'lessons learned', flexibility and tailoring are required to overcome unique resource barriers in a variety of ICU contexts.</p>	<p>By: Champions including at other successfully implemented sites, Pl, KT PLs. To: Champions, operational leads, frontline clinicians. How: In-person and virtual. How often: PRN. How well: Focus groups, discussions at A & F meetings.</p>	<p>Clinical decision support, champions, implementation support.</p>
<p>Rigidly defined professional roles vs empowerment and support</p> <p>Reluctance to expand traditional professional roles.</p>	<p>Goals setting (1.1 Behaviour, 1.3 Outcomes). 1.4 Action planning. 2.2 Feedback on behaviour. 5.1 Information about health consequences. 7.1 Prompts/cues. 9.1 Credible source. 12.1 Restructuring the physical environment.</p>	<p>1.1, 1.3, 1.4 Champions work with clinicians to set goals around pathway elements (eg, A & F reports) and strategise if targets are not met. 2.2 When A & F shows improvement as, eg, RTs take more ownership of LPV, this can alleviate concerns regarding expansion of roles. 5.1 Education is available to all disciplines to empower 'out of scope' conversations. 7.1 Prompts cue all members of the team toward evidence informed care. 9.1 Champions reinforce the ability to expand roles. 12.1 CDS empowers RTs and RNs.</p>	<p>All members of the multidisciplinary team are empowered to perform or suggest pathway management during daily bedside rounds. Team working toward a common goal of evidence informed care should lead to better outcomes.</p>	<p>By: Champions, Pl, KT PLs. To: Clinicians managing patients on the pathway. How: Face-to-face, email, virtual meetings. CDS available on unit and built into the CIS. How often: At initiation, monthly A & F, daily (reminders and CDS). How well: Survey, focus groups, discussions at A & F meetings.</p>	<p>Audit and feedback, education, reminders, clinical decision support, empowerment, champions.</p>
<p>Perception that it is not possible</p> <p>Not confident we can do this element of the pathway, especially within this time frame.</p>	<p>2.2 Feedback on behaviour. 3.1 Social support (unspecified). 5.1 Information about health consequences. 7.1 Prompts/cues. 6.1 Demonstration of the behaviour. 6.2 Social comparison/reminder of past success. 12.1 Restructuring of the physical environment. 12.5 Adding objects to the environment.</p>	<p>2.2 A & F to build confidence. 3.1 An environment of empowerment and support is facilitated by champions and KT PLs. 5.1 Provide rationale for pathway including timing. 7.1 Prompts/cues to increase confidence. 6.1 Demonstrations and simulations are available to build confidence. 6.2 Relay how other sites were able to perform the pathway and remind of past success if compliance drops. 12.1 CDS in CIS to guide clinicians. 12.5 Pocket cards and other reminders. Full length tape measures available to encourage measurement of heights to determine PBW.</p>	<p>ICU clinicians to be supported and educated so they feel capable and confident performing all pathway elements within time frames.</p>	<p>By: Pl, KT PLs, champions including at successfully implemented sites. To: Clinicians managing patients on the pathway. How: Face-to-face, email, virtual meetings. CDS available on unit and built into the CIS. How often: At initiation, PRN. How well: Post implementation survey, focus groups and discussion of 'timed' data at A & F meetings.</p>	<p>Audit and feedback, education, training, reminders, clinical decision support, empowerment.</p>

Continued

Table 3 Continued

Themes and belief statements		TIDieR			Key strategy
Selected intervention functions	Selected behaviour change techniques (BCTs)	Brief description of BCT intervention	Rationale (why)	Delivery (By and To whom, How, How well)	
Education, persuasion.	2.2 Feedback on behaviour. 2.7 Feedback on outcomes of the behaviour. 5.1 Information about health consequences. 9.1 Credible source.	2.2 A & F meetings and reports. 2.7 Share outcomes pre and post implementation at similar sites. 5.1 Evidence and rationale for pathway elements is presented and reinforced. 9.1 Education regarding evidence and A & F is provided by respected champions. Clinicians who agree with pathway are leveraged.	Build consensus through education and evidence for pathway interventions, thresholds, criteria and timing.	By: PI, KT PLs, champions including at successfully implemented sites. To: Clinicians managing patients on the pathway. How: In-person and virtual. How often: Initiation and PRN. How well: Survey/focus groups.	Audit and feedback, education, champions, implementation support.
*Lack of consensus on HRF/ARDS evidence-informed practice Agree/disagree with a pathway element. *Risks vs benefits of sedation					

All belief statements and Theoretical Domains Framework domains listed above are considered relevant for influencing behaviours for pathway implementation. Specific beliefs with an asterisk may be especially important to address because they represent barriers with the highest frequency of text excerpts. All BCTs were judged to meet APEASE criteria.

A & F, audit and feedback; APEASE, Affordability, Practicality, Effectiveness and cost-effectiveness. Acceptability, Side effects and safety and Equity; ARDS, acute respiratory distress syndrome; BC/Ts, behaviour change techniques; CDS, clinical decision support; CIS, clinical information system; HR, human resources; HRF, hypoxaemic respiratory failure; ICU, intensive care unit; KPIs, key performance indicators; KT PL, knowledge translation practice lead; LPV, lung protective ventilation; MD, physician; PBW, predicted body weight; PEEP, positive end expiratory pressure; PI, principal investigator; PRN, as required; RN, registered nurse; RT, respiratory therapist; SM, standardised management; TIDieR, template for intervention description and replication.

integrated pathways of care or suggest strategies to mitigate these barriers.

This study investigates specific beliefs not only about individual HRF and ARDS management components but also beliefs about a comprehensive care pathway. Many of the belief statements identified related to individual ARDS pathway elements are consistent with studies considering those elements in isolation (such as prone positioning or lung protective ventilation).^{12 55–57} For example, common barriers to prone positioning include perceptions about indications, contraindications and requisite staffing levels.^{12 55} Commonly identified barriers to lung protective ventilation (LPV) include a lack of knowledge about estimating lung size by predicted body weight as well as a perceived tension between deeper sedation to facilitate LPV and lighter sedation initiatives.⁵⁷ Many respondents viewed standardised management as reducing clinician ability to individualise care and had a negative view of ‘recipe’ protocols. This was common in other studies also^{20 46 57 58} but was expressed more frequently and more strongly in RTs and RNs than MDs in this study (see table 1; online supplemental eTable 6 and eFigure 5).

This study highlights qualitative differences in stated beliefs about HRF and ARDS pathway implementation between professional groups and hospital settings (online supplemental eTable 6,8 and eFigure 5,7). As examples, a skill deficit was identified for RTs and RNs, while for MDs a lack of evidence for an intervention was a key barrier. Regional sites identified staffing issues as a barrier more than other settings. RNs and regional ICUs frequently expressed a knowledge deficit (related to mechanical ventilation). The difference in barriers between multidisciplinary groups and types of settings highlights the importance of a multidisciplinary implementation strategy that targets specific BCTs and interventions to different groups and settings. This personalised approach has a greater probability of being effective. Given that not all behaviour change techniques are appropriate for critical care, the APEASE criteria helped identify only those BCTs that were appropriate. Describing the implementation strategy using the TIDieR framework facilitates reproducibility and scale to other jurisdictions. Our identified belief statements closely match barriers and strategies to guideline implementation in a recent systematic review that included 69 studies.²⁰ This included things such as lack of knowledge by users, incongruent attitudes such as lack of motivation, guideline specific factors such as low quality or absence of evidence and external factors such as organisational constraints. This suggests that barriers to pathway implementation and the implementation strategy identified in this study may be relevant to future interventions within the critical care field and other areas of acute medicine.

This study has several strengths including sampling a diverse population of ICU clinicians, a diversity of ICU settings, as well as being based on implementation science approaches including behaviour change theory. Our study, however, should be interpreted in the context

of its limitations. First, we acknowledge that the response rate may potentially be viewed as low which could represent a risk of missing a key theme. However, given that a large number of belief statements were distilled into nine themes and linked to all nine intervention strategies, we believe the risk of missing a novel barrier that is not addressed by our eight component implementation strategy is low. Second, we conducted a survey rather than an interview or focus group approach which may have limited some of the details of the barriers identified. Surveys did however provide other advantages such as being able to reach a much broader group of clinicians rather than a select few as in an interview. Third, this may have also provided limited insights to mitigation strategies. Fourth, our implementation strategy is based on beliefs about behaviour, and not on a quantitative assessment of practice. Fifth, the proposed implementation strategy is not tested prospectively. Ongoing and future studies including a pilot implementation (ClinicalTrials.gov NCT04070053) and a cluster randomised stepped wedge study (ClinicalTrials.gov NCT04744298) will assess if these implementation science-based strategies can improve clinical effectiveness outcomes.

CONCLUSIONS

Designing an implementation strategy for a critical care-based HRF and ARDS pathway that aims to improve the quality of patient care and increase adherence to evidence-based care should integrate strategies to mitigate clinician and setting specific barriers that are present to maximise the likelihood of success.

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