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

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.

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 eFigure1, 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

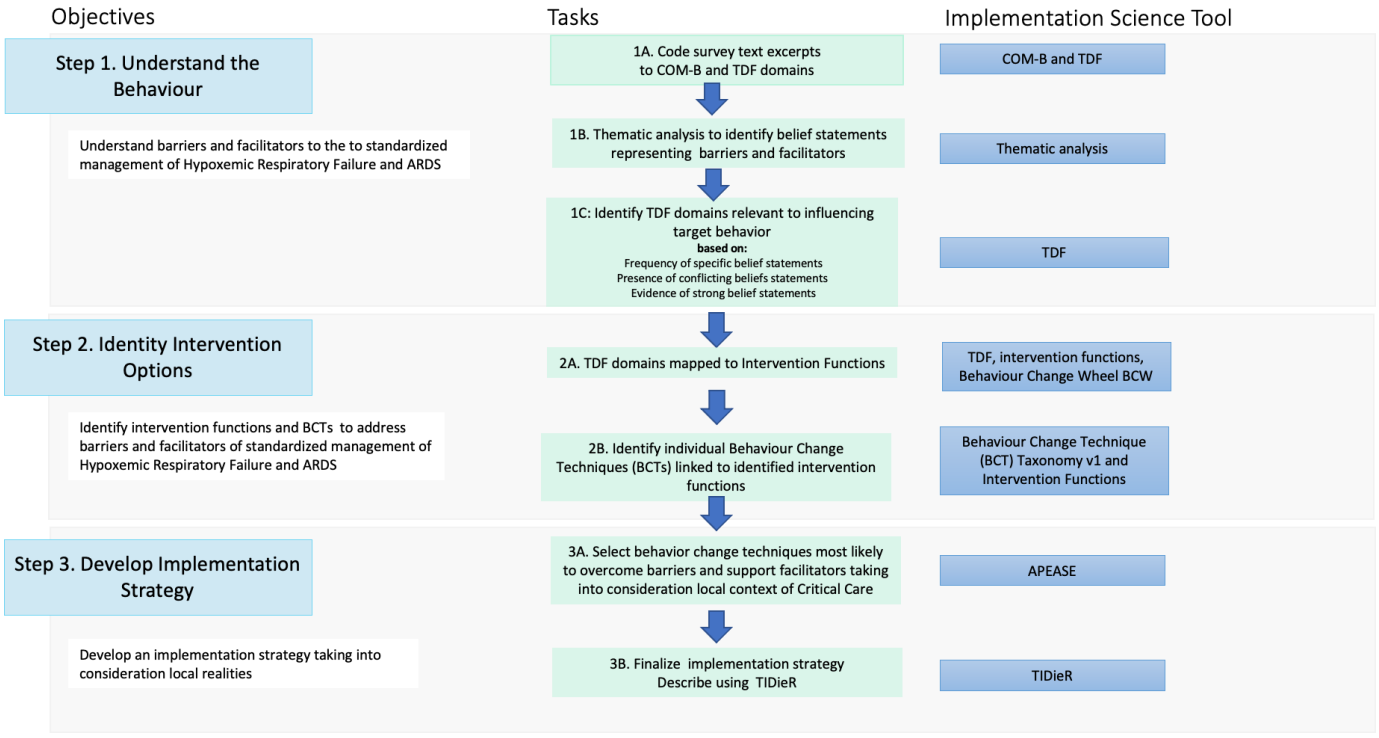

Figure 1 Study methods. A detailed description of the three step method to develop an implementation strategy. APEASE, Affordability, Practicality, Effectiveness and cost-effectiveness, Acceptability, Side effects, Equity; ARDS, acute respiratory distress syndrome; BCT, behaviour change technique; BCW, 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 behaviour[44] 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, 'Proning [placing patients in the prone position] is high maintenance and has a high risk of extubation especially when we are not at the bedside. [Proning 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 proning, an RN from a community hospital states, 'I believe early proning results in better outcomes for the patients. It is my experience that enacting this early results in shorter time spent proned, …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

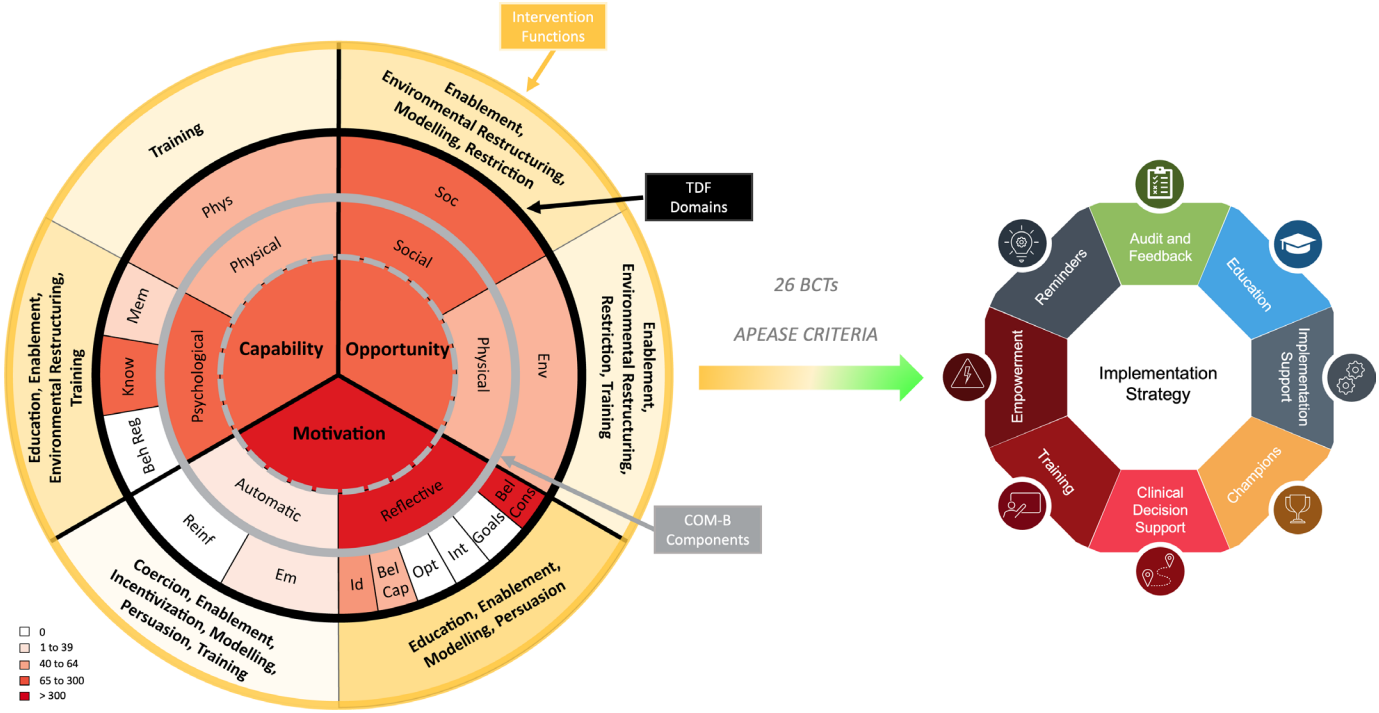

Figure 2 Barriers to evidence-based management of hypoxaemic respiratory failure and ARDS by the COM-B component and TDF domains with corresponding intervention functions and final implementation strategy. In the first three rings of the Behaviour Change Wheel (left), shading corresponds to the number 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.	Beliefs about consequences (293)	Reflective motivation	Disagree with a pathway element (procedure, intervention, threshold, criteria or timing).	151	12	Lack of consensus on HRF/ARDS best practice	Frequency Conflicting Strong
'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.			Agree with this pathway intervention, it would be beneficial.	77	12		Frequency Conflicting
'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.			Intervention is/might not be supported by evidence; I am not sure about the accuracy and reliability of this intervention.	30	7		Frequency
'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 SpO2 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.			This pathway intervention requires adequate sedation of pts and often they are not.	24	4	Risks vs benefits of sedation	Conflicting
'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.			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§**
'No clinical education of PF criteria for neuromuscular blockade or proning has been provided in our ICU.'– RN, R, 10. 'What do you mean by 'driving pressure'? clearly define more.'– RRT, R, 4. 'How long should we proning pts?'– RRT, C, 11.	Knowledge (71)¶	Psychological capability	Do not know a pathway intervention/have the education to perform pathway.	38	9	Lack of knowledge about pathway elements	Frequency
'Confession: I am personally unclear exactly how to use BOTH these pieces of data(height., PBW)for optimal tidal volume.'– MD, T, 2. 'Predicted body weight should be referred to as ideal body weight.'– RN, C, 2. 'Our beds do weights.'– RN, T, 2.			Unclear on definition and importance of height and PBW for LPV.	33	1		Frequency
'Rarely do we prone.' – RN, T, 1. 'X-rays are not done daily in our unit hence daily assessment for bilateral infiltrates or progression of it can't be made.' – RN, R, 9. 'We don't do optimal peep at [my site).'– RT, R, 6.	Social influences (66)¶	Social opportunity	My site rarely/never performs this pathway element.	66	11	Unit norms and practices	Frequency
'Rescreening should depend on clinical state not automatically at scheduled intervals.'– RN, R, 3. 'PT CONDITION DICTATES TREATMENT, BLIND NUMBERS MARE ONLY NUMBERS. THE OLD MURRAY SCORE WAS SO INACCURATE, AND I HAVE YET TO SEE AN ACCURATE RATING SYSTEM!'– RT, C, 3. 'Anyone can run numbers and follow 'recipe' protocols, treating sick pts requires skilled and experienced staff who can make decisions based on pt condition rather than an arbitrary 'Big Brother' protocol.'– RT, C, 5.	Memory, attention and decision-making (15)¶	Psychological capability	Pt care should be based on individual pt presentation, NOT a threshold in pathway, disagree with standardised management! Pt presentation and clinical judgement trump standardised management.	59	10	Conflicting feelings and beliefs about standardised management	Frequency Strong Conflicting
	Emotion (5)¶	Automatic motivation					
	Beliefs about capabilities (3)¶	Reflective motivation					
	Beliefs about consequences (36)¶						
'I think this [plateau pressure monitoring] should be a standard in the protocol.'– RN, T, 5. 'Does this group have an agreed upon peep study protocol? Can/will that be available to all sites?'– RN, R, 6. 'Is there a neuromuscular blockage protocol in terms of duration and/or vacations and long term affects?'– RT, T, 10.	Memory, attention and decision-making (35)¶	Psychological capability	A guideline or protocol for this pathway intervention is/may be needed.	35	11		Frequency 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	6	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	4		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	4	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	4	Skills deficit: Proning, PEEP study, oesophageal balloon	Strong
'Budget constraints removed [oesophageal balloon] monitoring from our site.'– RT, R, 7.	Environmental context and resources (21)¶	Physical opportunity	No access to pathway intervention.	12	4	Access to interventions and staff	Strong
'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.			Human resource are not available to perform the pathway intervention.	9	3		

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§

*Thematic analysis of coded data to identify belief statements and themes representing barriers and facilitators to pathway implementation.
†The number of survey response text excerpts that were generated into the belief statement in the column to the left.
‡The number of questions where at least 1 text excerpt (response) was coded to this belief statement out of 12.
§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.
¶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.
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.

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)
***Lack of knowledge about pathway elements** ► 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.	**Knowledge** Psychological capability	Education	**2.2 Feedback on behaviour** **2.3 Self-monitoring of behaviour** **2.7 Feedback on outcomes of the behaviour** **5.1 Information about health consequences** 5.2 Salience of consequences **5.3 Information about social and environmental consequences** **7.1 Prompts/cues** 9.1 Credible source
***Conflicting feelings and beliefs about standardised management** ► Treat based on individual patient presentation, NOT a threshold in pathway. ► Patient presentation and clinical judgement trumps standardised management.	**Memory, attention and decision processes**[a] Psychological capability	Training[a]	**2.2 Feedback on the Behaviour** **2.3 Self-monitoring of behaviour** **2.7 Feedback on the outcomes of the behaviour** **4.1 Instruction on how to perform a behaviour** **6.1 Demonstration of the behaviour** **8.1 Behavioural practice/rehearsal**
	Emotion[b] Automatic motivation	Environmental restructuring[a]	**7.1 Prompts/cues** **12.1 Restructuring the physical environment** 12.2 Restructuring the social environment **12.5 Adding objects to the environment**
	Beliefs about capabilities[c] Reflective motivation	Enablement[a,b,c]	**1.1 Goals setting (behaviour)** **1.2 Problem solving** **1.3 Goal setting (outcome)** **1.4 Action planning** **2.3 Self-monitoring of behaviour** **3.1 Social support (unspecified)** **3.2 Social support (practical)** **11.5 Review of behaviour goals** **11.7 Review outcome goals** **12.1 Restructuring of the physical environment** 12.2 Restructuring the social environment **12.5 Adding objects to the environment**
	Beliefs about consequences[d] Reflective motivation	Incentivisation[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** **5.1 Information about health consequences** 10.2 Material reward

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 *Education* 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	See *Training* BCTs listed above
		Environmental restructuring	See *Environmental restructuring* BCTs listed above
		Enablement	See *Enablement* 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).	**Physical skills** Physical capability	Training	See *Training* BCTs listed above
***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.	**Social influences** Social	Environmental restructuring	See *Environmental restructuring* BCTs listed above
	Opportunity	Modelling	See *Modelling* BCTs listed above
		Enablement	See *Enablement* BCTs listed above
		Restriction	No BCTs
Lack of access to interventions and staffing levels ► No access to a pathway intervention at my site. ► Human resources not available to perform the pathway.	**Environmental context and resources**	Training	See *Training* BCTs listed above
	Physical opportunity	Environmental restructuring	See *Environmental restructuring* BCTs listed above
		Enablement	See *Enablement* BCTs listed above
		Restriction	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 ► 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**	Education	See *Education* BCTs listed above
	Reflective	Persuasion	See *Persuasion* BCTs listed above
	Motivation	Modelling	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**	Education	See *Education* BCTs listed above
	Capabilities	Persuasion	See *Persuasion* BCTs listed above
	Reflective motivation	Modelling	See *Modelling* BCTs listed above
		Enablement	See *Enablement* BCTs listed above
***Lack of consensus on HRF/ARDS evidence-informed practice** ► 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** ► Can only perform this pathway intervention if patients are adequately sedated, and often they are not. ► Do not over sedate the patient.	**Beliefs about**	Education	See *Education* BCTs listed above
	Consequences	Persuasion	See *Persuasion* BCTs listed above
	Reflective motivation	Modelling	See *Modelling* BCTs listed above

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 *Conflicting feelings and beliefs about standardised management* were coded into four TDF domains as listed in column 2: *a=Memory, attention, and decision processes, b=Emotion, c=Beliefs about capabilities, d=Beliefs about consequences*. In column 3, the Interventions that were linked to these four TDF domains are noted with letters; for example, the intervention function, *Persuasion,* is linked to the TDF domains *b=Emotion, c=Beliefs about capabilities, d=Beliefs about consequences*. 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, *2.2 Feedback on the behaviour,* are from the BCT taxonomy V.1.[34]

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.

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

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

Continued

Table 3 Continued

Themes **and belief statements**	**Selected intervention functions**	**Selected behaviour change techniques (BCTs)**	**TIDieR**			
			Brief description of BCT intervention	**Rationale (why)**	**Delivery (By and To whom, How, How well)**	**Key strategy**
***Pathway intervention is not in line with unit norms and practices** We rarely or never perform this pathway element at my site	Environmental restructuring, modelling, enablement.	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.	3.1 Outreach to staff. 3.2 Site champions educate, train, provide feedback and troubleshoot issues that arise with pathway implementation. PI 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.	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.	**By:** Champions including at other successfully implemented sites, PI, 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.	Reminders, clinical decision support, champions, implementation support, empowerment.
Lack of access to interventions and staffing No access to this intervention or HR to perform.	Environmental restructuring, enablement.	1.2 Problem solving. 3.1 Social support (unspecified). 12.1 Restructuring of the physical environment.	1.2 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.	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.	**By:** Champions including at other successfully implemented sites, PI, 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.	Clinical decision support, champions, implementation support.
Rigidly defined professional roles vs empowerment and support Reluctance to expand traditional professional roles.	Education, persuasion, modelling.	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.	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.	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.	**By**: Champions, PI, 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.	Audit and feedback, education, reminders, clinical decision support, empowerment, champions.
Perception that it is not possible Not confident we can do this element of the pathway, especially within this time frame.	Education, persuasion, modelling, enablement.	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.	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.	ICU clinicians to be supported and educated so they feel capable and confident performing all pathway elements within time frames.	**By:** PI, 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.	Audit and feedback, education, training, reminders, clinical decision support, empowerment.

Continued

Table 3 Continued

Themes and belief statements	Selected intervention functions	Selected behaviour change techniques (BCTs)	TIDieR: Brief description of BCT intervention	TIDieR: Rationale (why)	TIDieR: Delivery (By and To whom, How, How well)	TIDieR: Key strategy
***Lack of consensus on HRF/ARDS evidence-informed practice** Agree/disagree with a pathway element. ***Risks vs benefits of sedation**	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.

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; BCTs, 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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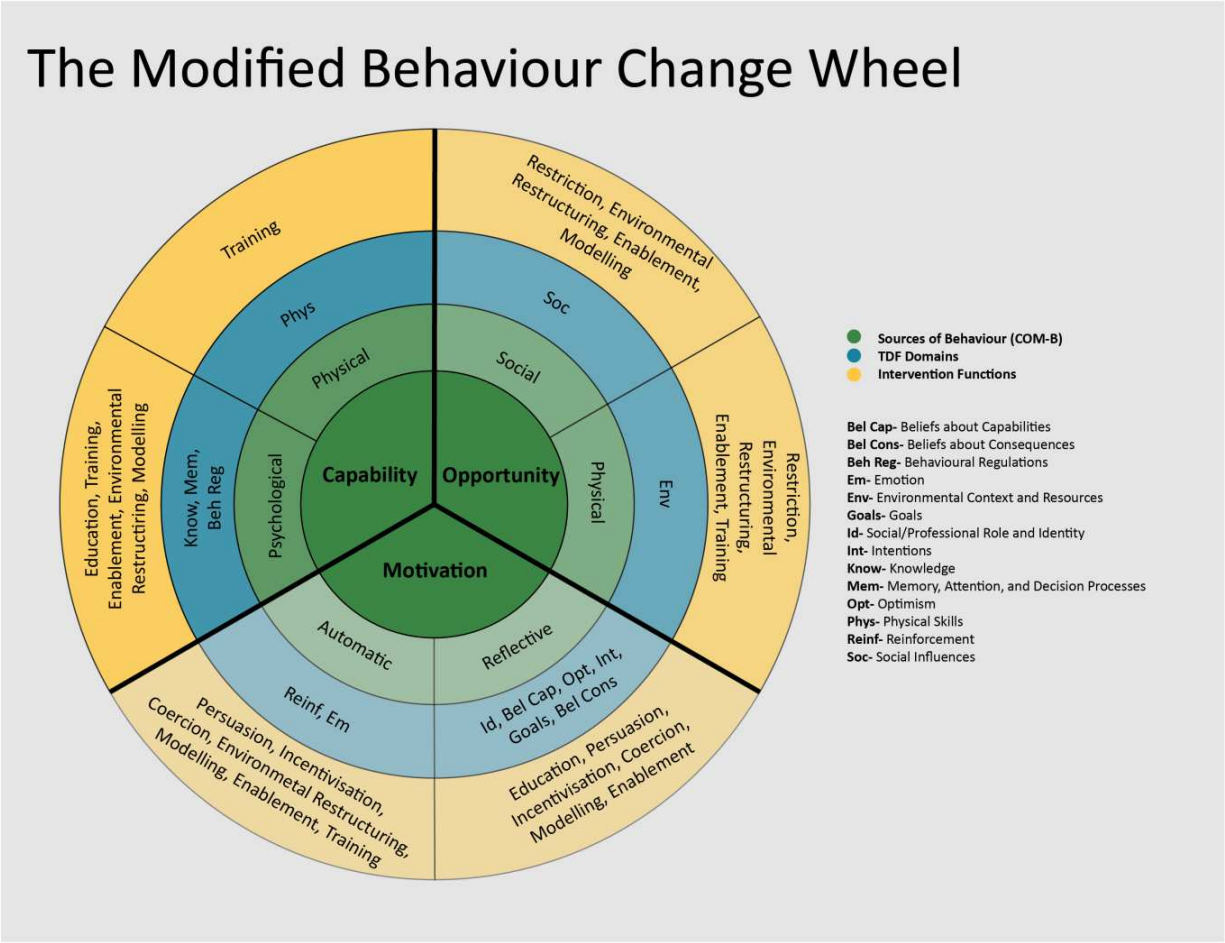
Designing a Behaviour Change Wheel guided implementation strategy for a Hypoxemic Respiratory Failure and ARDS care pathway that targets barriers

Supplemental Material

Contents



eFigure 1. The Modified Behaviour Change Wheel

Sources of Behaviour (COM-B)		Theoretical Domains Framework v2	Intervention Functions
Capability	Psychological	Knowledge (An awareness of the existence of something)	Education
		Memory, attention and decision processes (The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives)	Training Environmental restructuring Enablement
		Behavioural regulation (Anything aimed at managing or changing objectively observed or measured actions)	Education Training Modelling Enablement
	Physical	Skills (An ability or proficiency acquired through practice)	Training
Opportunity	Social	Social influences (Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours)	Restriction Environmental restructuring Modelling Enablement
	Physical	Environmental context and resources (Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence and adaptive behaviour)	Training Restriction Environmental restructuring Enablement
Motivation	Automatic	Emotion (A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event)	Persuasion Incentivisation Coercion Modelling Enablement
		Reinforcement (Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus)	Training Incentivisation Coercion Environmental restructuring
	Reflective	Social/professional role and identity (A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting)	Education Persuasion Modelling
		Beliefs about capabilities (Acceptance of the truth, reality or validity about an ability, talent or facility that a person can put to constructive use)	Education Persuasion Modelling Enablement
		Optimism (The confidence that things will happen for the best or that desired goals will be attained)	Education Persuasion Modelling Enablement
		Beliefs about Consequences (Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation)	Education Persuasion Modelling
		Intentions (A conscious decision to perform a behaviour or a resolve to act in a certain way)	Education Persuasion Incentivisation Coercion Modelling
		Goals (Mental representations of outcomes or end states that an individual wants to achieve)	Education Persuasion Incentivisation Coercion Modelling Enablement

eTable 1. COM-B (Capability, Opportunity, Motivation – Behaviour) components mapped to the Theoretical Domains Framework v2 and Intervention Functions[25,26]

eText 1. Survey open text questions

1. Do you have any comments regarding access to the listed interventions
   - Mechanical ventilation
   - Arterial Blood Gas (ABG) measurement
   - Portable chest x-ray
   - Optimal PEEP Study
   - Esophageal balloon
   - Recruitment maneuvers
   - Neuromuscular blockade
   - Proning
   - Inhaled vasodilators
   - On-site Extracorporeal Membrane Oxygenation (ECMO)

2. Do you have any comments or suggestions regarding documenting height and PBW in mechanically ventilated patients?

3. Do you have any comments or suggestions regarding HRF / ARDS screening?

4. Do you have any comments or suggestions regarding HRF / ARDS goals and early management?

5. Do you have any comments or suggestions regarding monitoring plateau pressures in the management of HRF / ARDS?

6. Do you have any comments or suggestions regarding PEEP management in patients with ARDS?

7. Do you have any comments or suggestions regarding the use of esophageal balloons in the management of ARDS?

8. Do you have any comments or suggestions regarding the use of Recruitments Maneuvers in the management of ARDS?

9. Do you have any comments or suggestions regarding sedatives in the management of ARDS?

10. Do you have any comments or suggestions regarding the use of neuromuscular blockade in the management of ARDS?

11. Do you have any comments or suggestions regarding proning in the management of ARDS?

12. Do you have any comments or suggestions regarding the use of inhaled vasodilators or ECMO in the management of ARDS?

eTable 2. Coding guideline

Theoretical Domains Framework v2[1]		Example statements made specific to the HRF/ARDS pathway[2]
Knowledge (An awareness of the existence of something)	Including knowledge of condition. Procedural knowledge	I am aware of the content and objectives of the HRF / ARDS pathway I know the content and objectives of the HRF / ARDS pathway I am aware of how to perform the interventions related to my scope of practice for eligible pts within the timeframes prescribed in the pathway
Coded to knowledge during creation of coding guideline during initial coding of 3 responses from each question: *Q2 R1 Confession: I am personally unclear exactly how to use BOTH [height & PBW) these pieces of data for optimal tidal volume* *Q2 R55 I would say accurate body weight would be more beneficial – RN* *Q3 R53 I do not know what at PF ratio is nor do I calculate the same* *Q11 R41 How long should we be proning patients?*		
Memory, attention and decision processes (MAD) (The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives)	Memory Attention Attention control Decision making Cognitive overload/tiredness	How often do you forget to perform the interventions in the pathway / evidence based care to pts with HRF & ARDS When I need to concentrate on providing interventions outlined in the pathway / best practice care to pts with HRF / ARDS I have no trouble focusing my attention When trying to focus my attention on performing pathway interventions / best practice care on pts with HRF / ARDS I have difficulty blocking out distracting thoughts The decision supports I have help me remember when to [perform this pathway intervention]
Coded to MAD during creation of coding guideline during initial coding of 3 responses from each question: *Q5 R45 Anyone can run numbers and follow 'recipe' protocols, treating sick patients requires skilled and experienced staff who can* ***make decisions based on patient condition*** *rather than an arbitrary 'Big Brother" protocol.* *Q5 R39 I think this [plateau pressure monitoring] should be a standard in the protocol Q8 R69 RMs need to be standardized across the zone* *Q3 R54 [Screen] Should be initiated when clinically appropriate, blindly screening all patients is wasteful and overrules clinical judgement.* *Q6 R6 Ensure a standardized protocol for PEEP* *Q7 R68 There is a skill to insertion [of Esophageal Balloons], the actual measurements and interpretation;* ***we will need a structured or organized approach*** *(Beliefs about Capabilities, Skills)* *Q7 R70* ***Guiding Criteria should be available for indications for insertions such as BMI>30, PF ratio etc****. Earlier application of this tool could provide better outcome and more preventive measures to worsening hypoxia (Also Beliefs about Consequences)* *Q3 R1 Once diagnosed, screening should stop (Beliefs about Consequences). Once recovering,* ***need a process for reevaluating.***		
Behavioural *regulation (BR) (Anything aimed at managing or changing objectively observed or measured actions)	Self-monitoring Breaking habit Action planning	I keep track of my overall progress towards ensuring I am providing pathway interventions / best practice care for patients on the pathway I am aware of my day-to-day behavior as I work towards providing interventions outlined in the pathway / evidence-based care
Coded to BR during creation of coding guideline during initial coding of 3 responses from each question: None during initial coding of 3 responses from each question.		
Skills (an ability or proficiency acquired through practice)	Skills development Competence Ability Interpersonal skills Practice Skill assessment	I have been trained how to perform pathway interventions e.g. LPV, proning, within my scope of practice for pts with HRF / ARDS I have the skills to perform pathway interventions within my scope of practice for patients with HRF / ARDS I have practiced pathway interventions within my scope of practice in pts with HRF / ARDS [at the right time]

Coded to Skills during creation of coding guideline during initial coding of 3 responses from each question:

Q11 R10 The multidisciplinary team MUST be skilled in proning, especially the RRT who is managing the airway.

Social influences (SI) (Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours)	Social pressure Social norms Group conformity Social comparisons Group norms Social support Power Intergroup conflict Alienation Group identity Modelling	Most people who are important to me, for eg senior colleagues, think that I should provide the interventions detailed in the pathway / standardized evidence based management to patients with HRF / ARDS Most people whose opinion I value for eg senior colleagues would approve me of providing the interventions detailed in the pathway / standardized evidence based management to patients with HRF / ARDS

Coded to SI during creation of coding guideline during initial coding of 3 responses from each question:

Q7 R10 Some Intensivists are not yet on board with Espohageal monitoring, promotion/education for these may be beneficial to patients (Also Social/prof id)
Q2 R2 Inconsistently done; [ht.] rarely measured prior to ventilator being set by RTs
Q2 R3 In theory this should happen but in practice it does not happen at our site (Also Beliefs about Consequences)
Q2 R4 While I agree with this [ht.] is definitely not done (Also Beliefs about Consequences)
Q3 R13 Our ICU rounds does not necessarily involve the RTs but rather nurse, MD and pharmacists. Our multidisciplinary rounds does not involve MDs and is more on care needed by pt. like needing PT, dietitian consults, etc.
Q3 R14 Multidisciplinary rounds are not completed on our unit. Rounds are also rarely done in any capacity
Q4 R1 Drs. here are noncompliant with multidisciplinary rounds. There has not been any clinical education in our ICU regarding Identifying or treating of HRF/ARDS
Q10 R29 [Neuromuscular Blockade is] Rarely required in our experience and no specific paralytic drug needed
Q11 R56 Proning not used in current unit.

Environmental context and Resources (ENV) (Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence and adaptive behaviour)	Environmental stressors Resources/material resources Organisational culture/climate Salient events/critical incidents Person × environment interaction Barriers and facilitators	The ICU I work in has the necessary equipment to initiate pathway interventions Within my ICU context, with the human resources available in my ICU we can provide all pathway interventions Communication (verbal and written) between team members (physician/RT/RN) is clear enough for me to initiate and/or manage prone positioned patients with moderate-severe ARDS

Coded to ENV during creation of coding guideline during initial coding of 3 responses from each question:

Q1 R1 I have access to all [interventions on the pathway], some I rarely perform, such as RM.

Emotion (A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event)	Fear Anxiety Affect Stress Depression Positive/negative affect Burn-out	I feel anxious about providing some of the interventions on the pathway

Coded to Emotion during creation of coding guideline during initial coding of 3 responses from each question:

Q5 R45 Anyone can run numbers and follow 'recipe' protocols, treating sick patients requires skilled and experienced staff who can make decisions based on patient condition rather than an arbitrary 'Big Brother" protocol. (Also Beliefs about Capabilities, Beliefs about consequences, and Memory, attention, and decision processes)
Q3 R25 PT CONDITION DICTATES TREATMENT, BLIND NUMBERS MARE ONLY NUMBERS. THE OLD MURRAY SCORE WAS SO INACCURATE,, AND I HAVE YET TO SEE AN ACCURATE RATING SYSTEM! (Also Beliefs about Capabilities, Beliefs about consequences, and Memory, attention, and decision processes)
*Q3 R9 we did the ALI 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 (Also Beliefs about Capabilities, Emotion).*

Reinforcement* (Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus)	Rewards (proximal/distal, valued/not valued, probable/ improbable) Incentives Punishment Consequences Reinforcement Contingencies Sanctions	Interventions on the pathway are valued in my ICU as a life-saving therapies I receive encouragement and support from my ICU to initiate pathway interventions

Coded to Reinforcement during creation of coding guideline during initial coding of 3 responses from each question:

None during initial coding of 3 responses from each question.

Social/professional role and Identity (SPR) (A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting)	Professional identity Professional role Social identity Identity Professional boundaries Professional confidence Group identity Leadership Organisational commitment	As a [profession], it is my job to perform pathway interventions in with pts with HRF /ARDS It is my responsibility as a [profession] to perform pathway intervention with HRF /ARDS Doing pathway intervention in with pts with HRF / ARDS is consistent with my [profession] Doing pathway intervention in with pts with HRF / ARDS is consistent with my [profession]

Coded to SPR during creation of coding guideline during initial coding of 3 responses from each question:

*Q8 R27 RRTs perform recruitment maneuvers when they are appropriate and patient meets criteria without meeting exclusion criteria. **RRTs should only seek approval if** any contraindications are present (Also Beliefs about Capabilities)*
*Q5 R25 [Pathway provides] a good guideline [for performing plateau pressures] then if patient is deteriorating the **RT should have the freedom to decide** on frequency of plateau pressures (Also Beliefs about Capabilities, Memory and Decision Processes)*
*Q8 R14 Recruitment maneuvers should be performed as indicated with the **permission of the RN** to maintain stable hemodynamics. (Also Beliefs about Consequences).*

Beliefs about capabilities (BCap) (Acceptance of the truth, reality or validity about an ability, talent or facility that a person can put to constructive use)	Self-confidence Perceived competence Self-efficacy Perceived behavioural control Beliefs Self-esteem Empowerment Professional confidence	I am confident that I can perform pathway interventions in patients with HRF / ARDS at the appropriate time and / or threshold when there is little time I am confident that if I wanted I could perform pathway interventions at the appropriate time and / or threshold for patients with HRF / ARDS I am confident that if I wanted I could perform pathway interventions at the appropriate time and / or threshold for patients with HRF / ARDS

Coded to BCap during creation of coding guideline during initial coding of 3 responses from each question:

Q5 R26 In an ideal world, I would like to say the RRT should determine appropriateness in measuring and complete, however, if the goal is to look at a way of standardizing the management, ***I feel that there is too much variability in individuals practice as to what may deemed "appropriate****." (Also Social & Professional ID)*
Q5 R14 I don't agree that plateau pressures should be measured within 1H of inclusion only because it is not often easy to get a well sedated pt within that time frame.

Optimism (The confidence that things will happen for the best or that desired goals will be attained)	Optimism Pessimism Unrealistic optimism Identity	With regard to performing pathway interventions at the appropriate time / threshold I usually expect the best

Coded to Optimism during creation of coding guideline during initial coding of 3 responses from each question:

Q1 R3 We can probably get EB figured out but do not use them

Beliefs about consequences (BCon) (Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation)	Beliefs Outcome expectancies Characteristics of outcome expectancies Anticipated regret Consequents	If I provide pathway interventions to patients with HRF / ARDS at the appropriate time / threshold, it can save lives

Coded to BCon during creation of coding guideline during initial coding of 3 responses from each question:

Q2 R38 Accuracy [PBW] is rather iffy +/-25% -
Q2 R22 [Regarding height and PBW] it is a good idea
Q3 R2 The challenge is not screening but ensuring the correct patients; those with no other cause of HRF
Q3 R7 If it is common practice at sites to do a daily steady-state ABG [SI], then they are already rescreened for HRF even if they were screened negative for ARDS. Re-screening for ARDS should be a discussion with the team if there was a clinical indication other than p/f ratio that the patients condition has changed. If a Q24h ARDS screen was policy, patients who screened negative b/c of heart failure, would be re-screened again the next day. Seems like a waste of time and money when you know the reason for p/f ratio is cardiac in nature.
Q3 R8 I think that you would need to ensure that pts are on an optimal PEEP prior to screenings to ensure that they are adequately recruited. Particularly in the setting of increasing FiO2. Use of esophageal balloons would be helpful. The criteria of a PF ratio of <300 would potentially capture a large population of pts to enter further screening and subject more pt to CXR. For example a pt on 0.30 and having a PaO2 of 80 would fall into the screening category. Might be a tad bit overkill.
Q3 R16 Im not sure that all patients should be automatically screened daily for ARDS.
Many of our ventilated patients require long term ventilation, and many of them do not have an arterial line in place the entire time. I do not believe that a stable patient should be subjected to daily arterial pokes just for the sake of a screening tool that may not ever apply to them. I think the patient's condition and diagnosis should play a part in whether they are screened daily.
Q3 R19 My population has a low rate of ARDS and screening would identify very few such cases (Also Knowledge)
Q4 R4 there is a clear difference between a patient with HRF and a P/F of 270 and an ARDS patient with a P/F of 140. In the former I would be happy with a supported (PSV) rather than a controlled mode of ventilation...Hence, I would recommend separating the 2 types of patients when asking us to complete this survey if you want valuable information to guide practice!
Q4 R16 6-8 ml/kg is to high for current lung protective strategies.
Q4 R25 VT goals of 6-8mL/kg cause a lot of problems on patients that are breathing spontaneously on AC - VC. I find patients on RR=34, PEEP=12, and PIP=18. Pt is clearly struggling to breath. Switched to PCV of 30/12 and VTs are greater than 8mL/kg and the intensivist gets mad. (Also Emotion)
Q5 R21 plateau pressures should only be performed on sedated patients as you cannot get an accurate measurement on a spontaneously breathing patient
Q9 R43 Sedatives may be one option. Would suggest treat pain first with analgesia. With ARDS, NMBA may be required.
Q5 R14 I also don't agree that plateau pressures should be repeated Q12H but instead as needed and more often if goals are not being achieved and adjustments are required.
Q9 R1 I think this is very important and [sedation] goals should be clearly defined and changed as required in the order sets. I believe a RASS of -4 would be more appropriate but that is simply from observing and working with pt with severe ARDS. I believe that time has to be given for ARDS to resolve and sedation with a RASS goal is important. After all we don't expect people to walk with a broken leg after a few days
Q9 R6 Sedatives are a necessary evil. We understand that use of sedatives can effect long term outcomes (issues with delirium and neuropathies). Smallest dose to achieve ventilation/oxygenation goals.

Q10 R28 In addition to pf ratio, ability to ventilate with goal tidal volumes, etc without asynchrony in ARDS pts should be consideration for paralytics
Q12 R33 Again, cannot emphasize enough of taking each individual patient into consideration, examining all relevant factors and pertinent information (i.e.. labs, diagnostics, physical assessment findings, etc.). Are we permitting any individual variation in patient management and care? (Also Memory and Decision Processes, Beliefs about Capabilities, Emotion)
Q1 R5 EB would be highly beneficial!!!

Goals* (Mental representations of outcomes or end states that an individual wants to achieve)	Goals (distal/proximal) Goal priority Goal/target setting Goals (autonomous/controlled) Action planning Implementation intentions	High rates of interventions on the pathway, for example proning, should be a goal in my ICU
Coded to Goals: None during initial coding of 3 responses from each question.		
Intentions (A conscious decision to perform a behaviour or a resolve to act in certain way)	Stability of intentions Stages of change model Transtheoretical model and stages of change	I intend to provide pathway care for patients with HRF / ARDS is the next few months

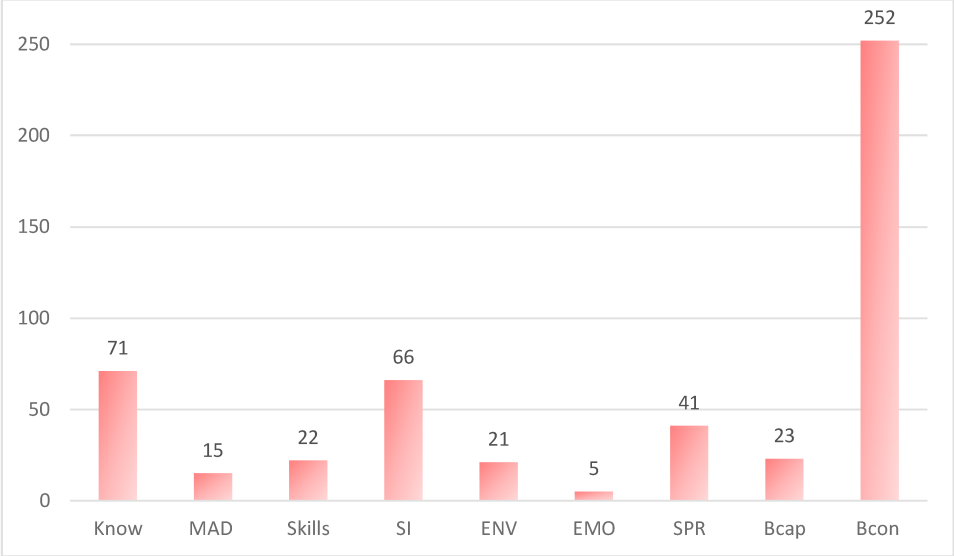
eTable 3. Matrix of relevant Behaviour Change Techniques for Intervention Functions	
Intervention Function	Individual BCTs
Education	Most frequently used BCTs: • Information about social and environmental consequences • Information about health consequences • Feedback on outcome(s) of the behaviour • Feedback on behaviour • Prompts/cues • Self-monitoring of behaviour Less frequently used BCTs: ➢ Biofeedback ➢ Self-monitoring of outcome(s) of behaviour ➢ Cue signalling reward ➢ Satiation ➢ Information about antecedents ➢ Re-attribution ➢ Behavioural experiments ➢ Information about emotional consequences ➢ Information about others' approval
Persuasion	Most frequently used BCTs: • Credible source • Information about social and environmental consequences • Information about health consequences • Feedback on outcome(s) of the behaviour • Feedback on behaviour Less frequently used BCTs: ➢ Biofeedback ➢ Focus on past success ➢ Verbal persuasion about capability ➢ Framing/reframing ➢ Re-attribution ➢ Identity associated with changed behaviour ➢ Information about emotional consequences ➢ Information about others' approval ➢ Identification of self as role model ➢ Salience of consequences ➢ Social comparison
Incentivisation	Most frequently used BCTs: • Information about health consequences • Feedback on outcome(s) of the behaviour • Feedback on behaviour • Self-monitoring of behaviour • Monitoring of behaviour by others without evidence of feedback Less frequently used BCTs: ➢ Biofeedback ➢ Paradoxical instructions ➢ Self-monitoring of outcome(s) of behaviour ➢ Cue signalling reward ➢ Remove aversive stimulus ➢ Reward approximation ➢ Reward completion

	➢ Situation specific reward ➢ Reward incompatible behaviour ➢ Reduce reward frequency ➢ Reward alternate behaviour ➢ Remove punishment ➢ Social reward ➢ Material reward ➢ Material reward (outcome) ➢ Self-reward ➢ Non -specific reward ➢ Incentive ➢ Behavioural contract ➢ Commitment ➢ Discrepancy between current behaviour and goal Imaginary reward
Coercion	Most frequently used BCTs: • **Feedback on outcome(s) of the behaviour** • **Feedback on behaviour** • **Self-monitoring of behaviour** • **Monitoring of behaviour by others without evidence of feedback** • **Monitoring outcome of behaviour by others without evidence of feedback** Less frequently used BCTs: ➢ Biofeedback ➢ Self-monitoring of outcome(s) of behaviour ➢ Remove access to reward ➢ Punishment ➢ Imaginary punishment ➢ Future punishment ➢ Behaviour cost ➢ Remove reward ➢ Behavioural contract ➢ Commitment ➢ Discrepancy between current behaviour and goal ➢ Incompatible beliefs ➢ Anticipated regret
Training	Most frequently used BCTs: • **Demonstration of the behaviour** • **Instruction on how to perform a behaviour** • **Feedback on outcome(s) of the behaviour** • **Feedback on behaviour** • **Self-monitoring of behaviour** • **Behavioural practice/rehearsal** Less frequently used BCTs: ➢ Biofeedback ➢ Self-monitoring of outcome(s) of behaviour ➢ Habit reversal ➢ Graded tasks ➢ Behavioural experiments ➢ Mental rehearsal of successful performance ➢ Self-talk ➢ Self-reward
Restriction	*No BCTs in BCTTv1 are linked to this intervention function because they are focused on changing the way that people think, feel and react rather than the way the external environment limits their behaviour.*

Environmental restructuring	Most frequently used BCTs: • Adding objects to the environment • Prompts/cues • Restructuring the physical environment Less frequently used BCTs: ➢ Cue signalling reward ➢ Remove access to the reward ➢ Remove aversive stimulus ➢ Satiation ➢ Exposure ➢ Associative learning ➢ Reduce prompt/cue ➢ Restructuring the social environment
Modelling	Most frequently used BCTs: • Demonstration of the behaviour
Enablement	Most frequently used BCTs: • Social support (unspecified) • Social support (practical) • Goal setting (behaviour) • Goal setting (outcome) • Adding objects to the environment • Problem solving • Action planning • Self-monitoring of behaviour • Restructuring the physical environment • Review of behaviour goals • Review outcome goals Less frequently used BCTs: ➢ Social support (unspecified) ➢ Reduce negative emotions ➢ Conserve mental resources ➢ Pharmacological support ➢ Self-monitoring of outcome(s) of behaviour ➢ Behaviour substitution ➢ Overcorrection ➢ Generalization of a target behaviour ➢ Graded tasks ➢ Restructuring the social environment ➢ Avoidance/reducing exposure to cues for the behaviour ➢ Distraction ➢ Body changes ➢ Behavioural experiments ➢ Mental rehearsal of successful performance ➢ Focus on past success ➢ Self-talk ➢ Verbal persuasion about capability ➢ Self-reward ➢ Behavioural contract ➢ Commitment ➢ Discrepancy between current behaviour and goal

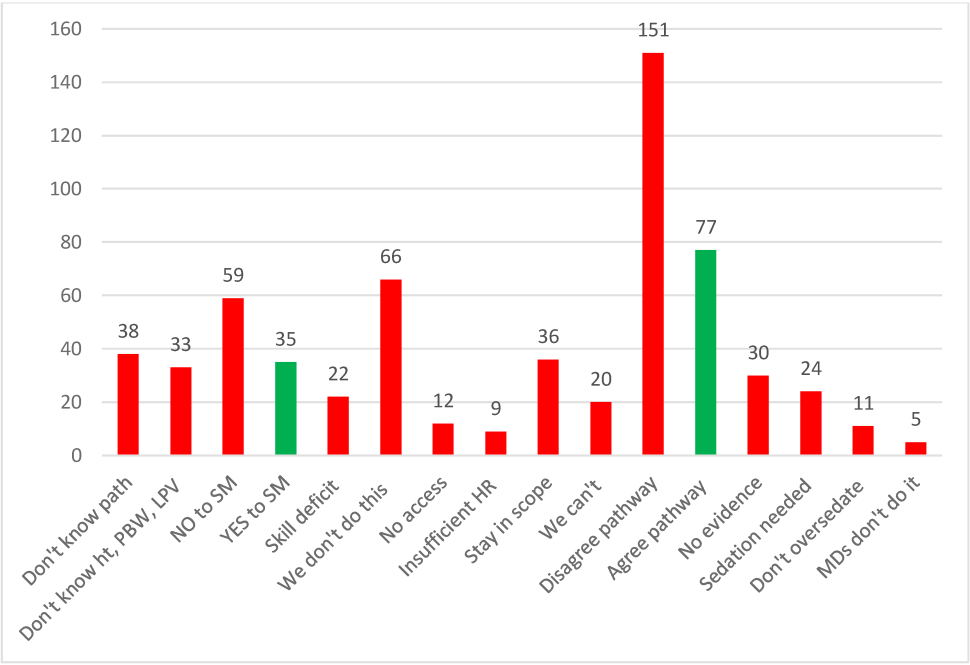
eTable 4. Characteristics of open text survey respondents

	Survey respondents (n=692)	Survey respondents open text (n=266)
Discipline	Number (%)	Number (%)
Nurse Practitioner	4 (1)	1 (0.4)
Registered Nurse	410 (59)	115 (43)
Respiratory Therapist	229 (33)	123 (46)
Physician	49 (7)	27 (10)
Hospital type		
Tertiary	335 (48)	130 (49)
Community	252 (36)	96 (36)
Regional	105 (15)	40 (15)



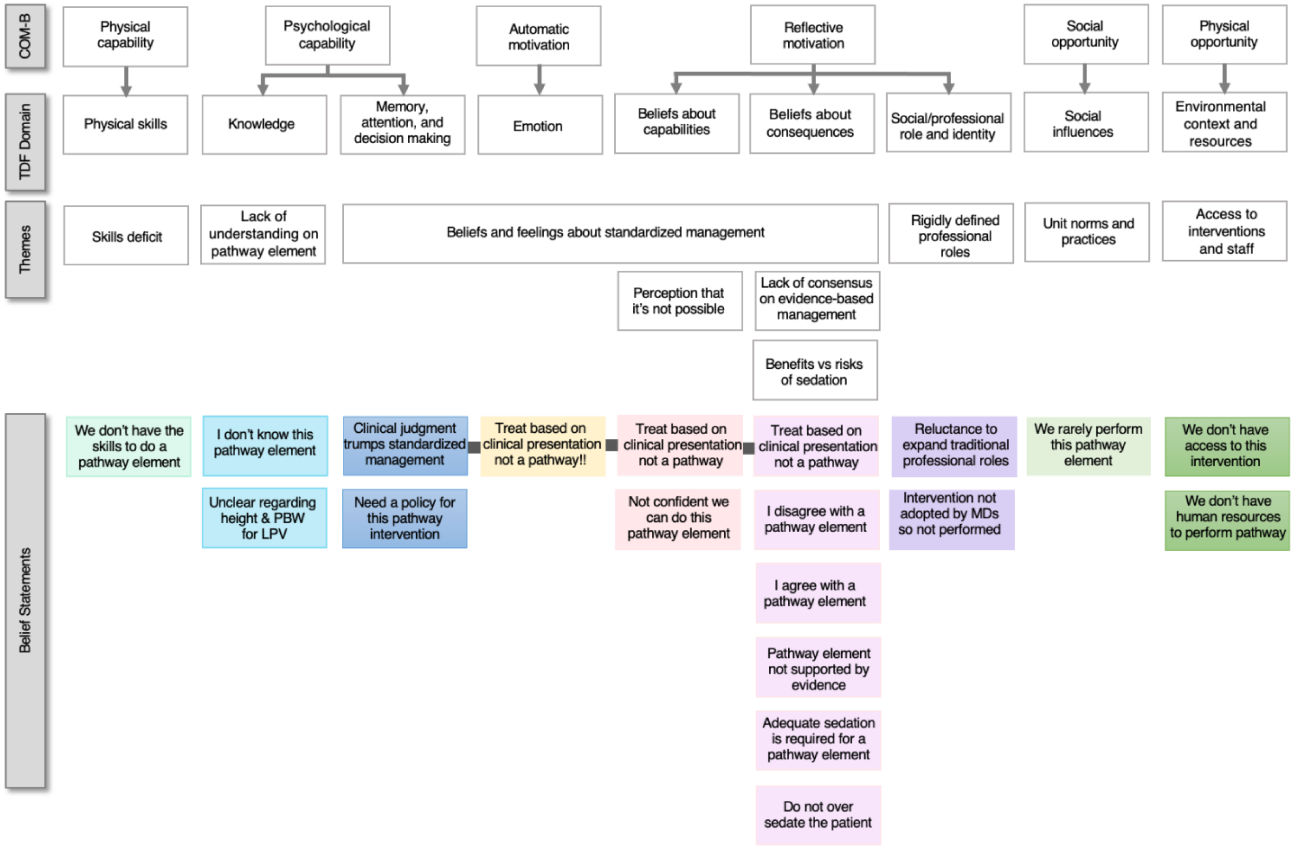
eFigure 2. Frequency and proportion of text excerpts representing a barrier to pathway implementation by TDF domain

Of the 628 text excepts determined to be relevant to the target behaviour, 516 were determined to be barriers to the target behaviour. Bcap=Beliefs about capabilities. Bcon=Beliefs about consequences. Emo=Emotion. Env=Environmental context and resources. Know=knowledge. MAD=memory, attention, and decision making. SI=Social influences. Skills=physical skills.



eFigure 3. Frequency of text excerpts assigned to belief statements.

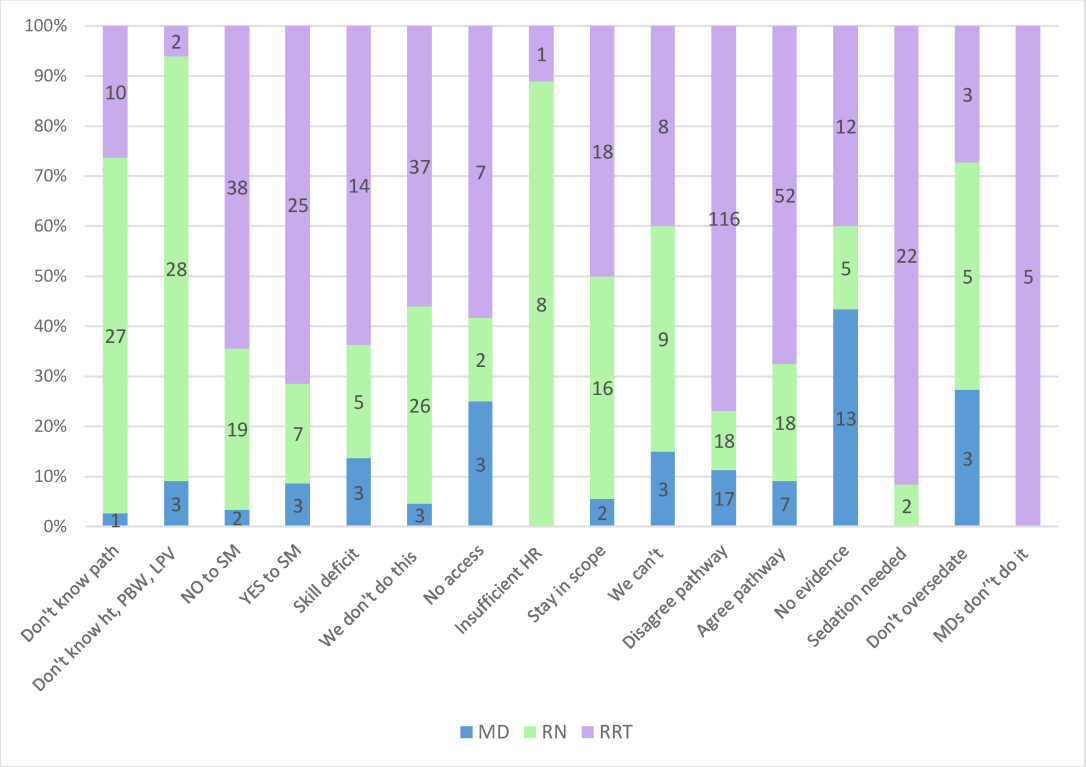
628 text excerpts were detemined to be relevant to the relevant to the target behaviour. Ht=height. HR=Human resources. LPV=lung protective ventilation. PBW=predicted body weight. SM=standardized management.



eFigure 4. The relationship between identified belief statements, themes, and relevant TDF domains and COM-B components

eTable 5. Frequency of text excerpts assigned to identified belief statements by discipline and hospital type

Belief statement	Total	MD	RN	RRT	Comm	Regional	Tertiary
We (I or my colleagues) don't know a pathway intervention or have the education to perform the pathway.	**38**	1	27	10	11	18	9
Unclear on definition and importance of height (ht.) and Predicted Body Weight (PBW) for Lung Protective Ventilation (LPV).	**33**	3	28	2	16	6	11
This should be based on individual patient presentation, NOT a threshold in pathway; NO to standardized management!	**59**	2	19	38	19	22	18
A guideline or protocol for this pathway intervention is / may be needed.	**35**	3	7	25	10	8	17
We do not have the skills to perform this pathway intervention; training is needed (proning, esophageal balloon, optimal PEEP study).	**22**	3	5	14	9	6	7
We rarely or never perform this pathway element at my site.	**66**	3	26	37	22	14	30
We do not have access to this pathway intervention at my site.	**12**	3	2	7	6	3	3
Human resources are not available to perform the pathway.	**9**		8	1		7	2
Reluctance to expand traditional professional roles; stay in your lane.	**36**	2	16	18	13	8	15
This pathway intervention has not been adopted by MDs so it's not being done.	**5**			5	4		1
Not confident we can do this element of the pathway, especially within this timeframe.	**20**	3	9	18	9	2	9
Disagree with a pathway element e.g. procedure, intervention, threshold, criteria, or timing.	**151**	17	18	116	47	19	85
Agree with this intervention on the pathway, it would be beneficial.	**77**	7	18	52	28	14	35
Is not or might not be supported by evidence; I'm not sure about the accuracy and reliability of this intervention.	**30**	13	5	12	15	6	9
Can only perform this pathway intervention if patients are adequately sedated, and often they are not.	**24**		2	22	8		16
Do not over sedate the patient.	**11**	3	5	3	5	2	4
	628	63	195	370	222	135	271



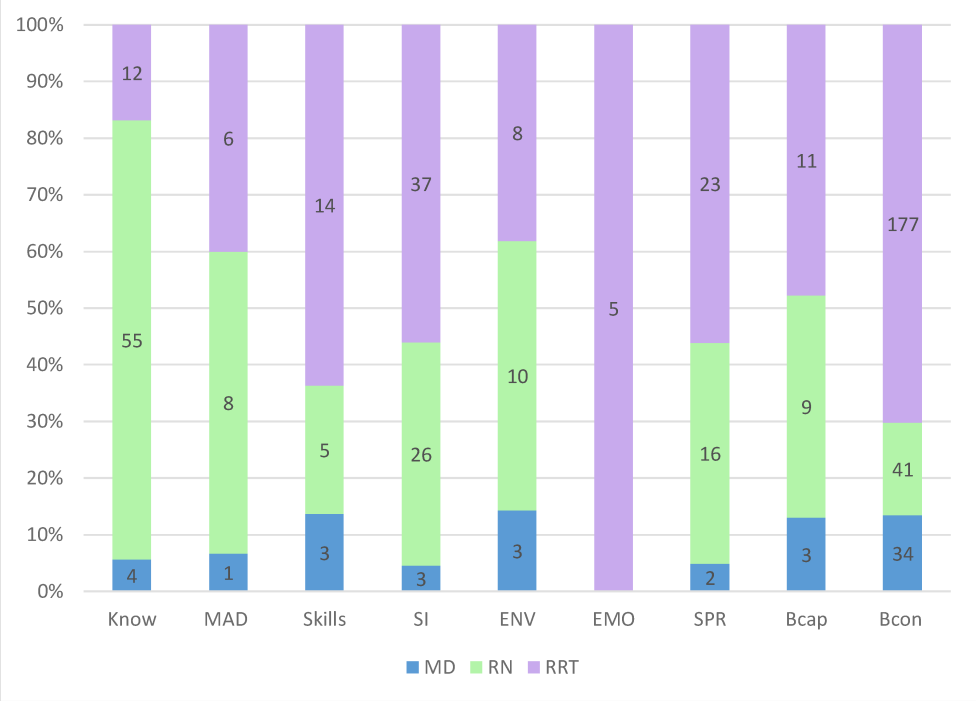
eFigure 5. Frequency and proportion of text excerpts assigned to belief statements by discipline.

628 text excerpts were detemined to be relevant to the relevant to the target behaviour. For each belief statement in eFigure 3, we broke our proportions by discipline. Ht=height. HR=Human resources. LPV=lung protective ventilation. PBW=predicted body weight. SM=standardized management.

eTable 6. Belief statements with the highest number of survey text excerpts by discipline

		Belief statements
MD	1	I disagree with a pathway element (B)
	2	Pathway element is not supported by evidence (B)
	3	I agree with a pathway element (F)
RT	1	I disagree with a pathway element (B)
	2	I agree with a pathway element (F)
	3	Treat based on clinical presentation not a pathway / no to standardized management (B)
	4	We rarely perform this pathway element (B)
RN	1	I'm unclear on height and Predicted Body Weight (PBW) for Lung Protective Ventilation (LPV) (B)
	2	I don't know this pathway element (B)
	3	We rarely perform this pathway element (B)

MD=physician. RT=Respiratory Therapist. RN= Registered Nurse. B=barrier. F=facilitator



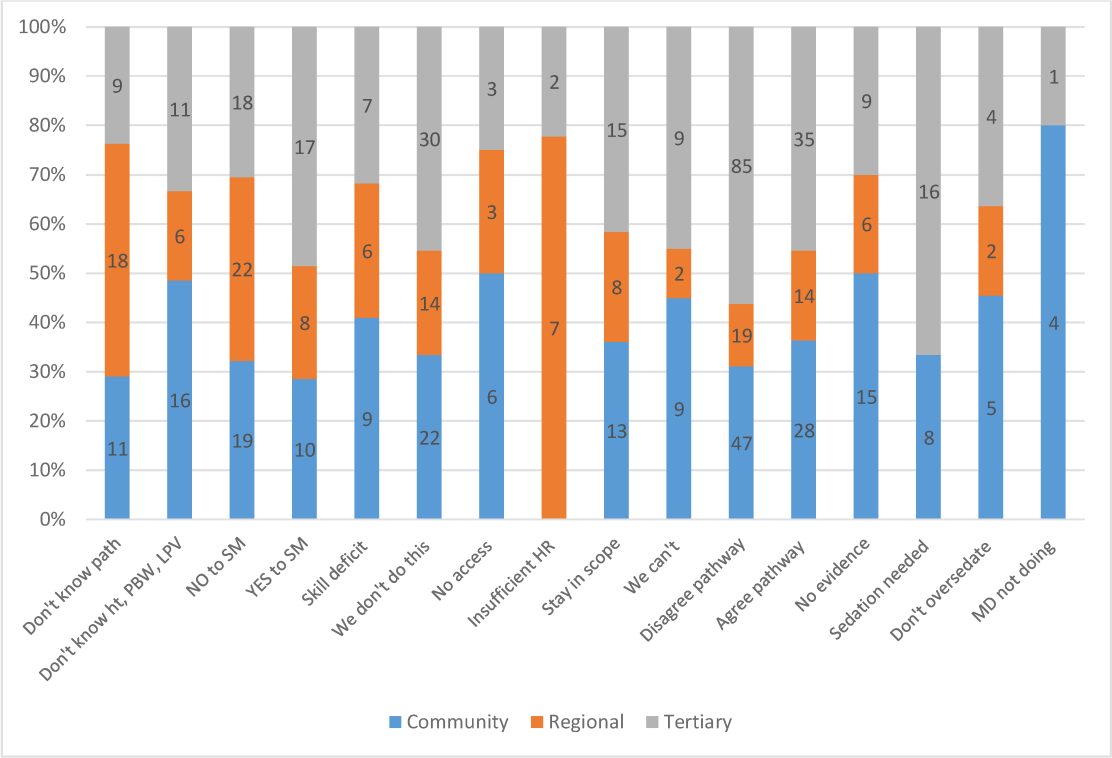
eFigure 6. Frequency and proportion of text excerpts representing a barrier to pathway implementation by discipline by TDF domain.

Of the 628 text excepts determined to be relevant to the target behaviour, 516 were determined to be barriers to the target behaviour. For each TDF domain in eFigure 2, we broke out proportions by discipline. Bcap=Beliefs about capabilities. Bcon=Beliefs about consequences. Emo=Emotion. Env=Environmental context and resources. Know=knowledge. MAD=memory, attention, and decision making. SI=Social influences. Skills=physical skills. SPR=Social and professional identity.

eTable 7. TDF domains with the highest number of survey text excerpts representing a **barrier** by discipline

		TDF Domain
MD	1	Beliefs about consequences (34 excerpts)
	2	Knowledge (4 excerpts)
RT	1	Beliefs about consequences (177 excerpts)
	2	Social Influences (37 excerpts)
	3	Social and professional identity (23 excerpts)
RN	1	Knowledge (55 excerpts)
	2	Beliefs about consequences (41 excerpts)
	3	Social Influences (26 excerpts)

MD=physician. RT=Respiratory Therapist. RN=Registered Nurse.



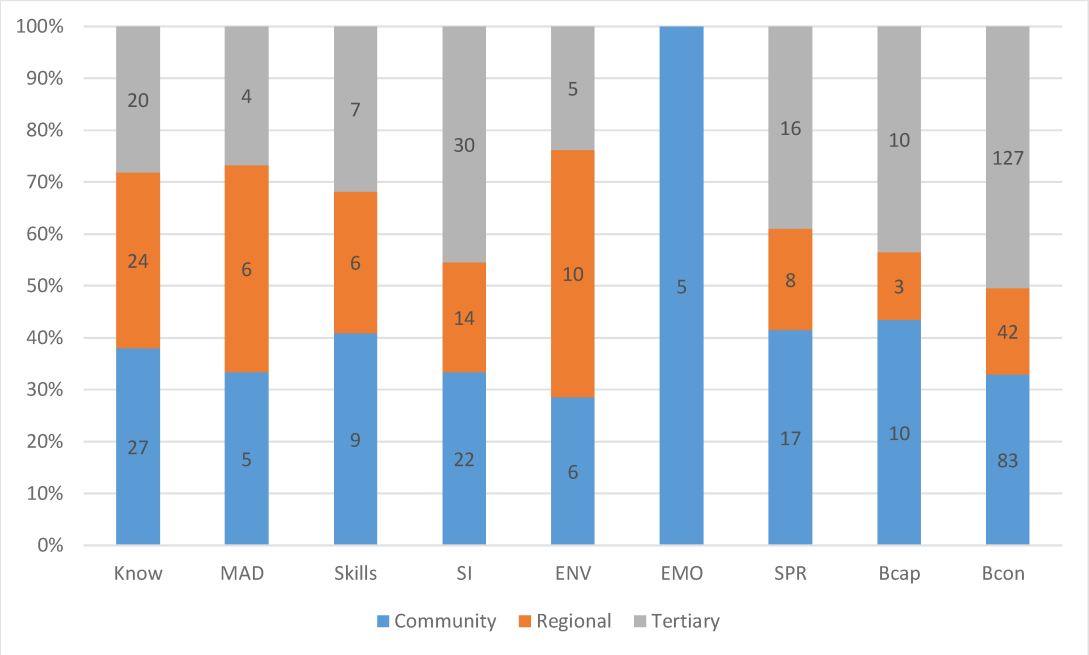
eFigure 7. Frequency and proportion of text excerpts assigned to belief statements by hospital type.

628 text excerpts were detemined to be relevant to the relevant to the target behaviour.For each belief statements in eFigure 3, we broke our proportions by hospital type. Ht=height. HR=Human resources. LPV=lung protective ventilation. PBW=predicted body weight. SM=standardized management.

eTable 8. Belief statements with the highest number of survey excerpts by hospital type

Hospital type		**Belief statements**
Regional	1	Treat based on clinical presentation not a pathway (B)
	2	I disagree with a pathway element (B)
	3	I don't know this pathway element (B)
Community	1	I disagree with a pathway element (B)
	2	We rarely perform this pathway element (B)
	3	Treat based on clinical presentation not a pathway (B)
Tertiary	1	I disagree with a pathway element (B)
	2	We rarely perform this pathway element (B)
	3	Treat based on clinical presentation not a pathway (B)

B=barrier. F=facilitator



eFigure 8. Proportion of text excerpts representing a barrier to pathway implementation by hospital type and TDF domain

Of the 628 text excepts determined to be relevant to the target behaviour, 516 were determined to be barriers to the target behaviour. For each TDF domain in eFigure 2, we broke out proportions by hospital type. Bcap=Beliefs about capabilities. Bcon=Beliefs about consequences. Emo=Emotion. Env=Environmental context and resources. Know=knowledge. MAD=memory, attention, and decision making. SI=Social influences. Skills=physical skills. SPR=Social and professional identity.

eTable 9. Theoretical Domains Framework domains with the highest number of survey excerpts representing a **barrier** by hospital type

Hospital type		**TDF Domain**
Regional	1	Beliefs about Consequences (42 excerpts)
	2	Knowledge (24 excerpts)
	3	Social Influences (14 excerpts)
Community	1	Beliefs about Consequences (83 excerpts)
	2	Knowledge (27 excerpts)
	3	Social Influences (22 excerpts)
Tertiary	1	Beliefs about Consequences (127 excerpts)
	2	Social Influences (30 excerpts)
	3	Knowledge (20 excerpts)

eTable 10. Behaviour Change Techniques (BCTs) evaluated using the APEASE criteria

		Meets APEASE criteria					
No.	Candidate Behaviour Change Technique (BCT)	Affordable	Practical	Effective	Acceptable	Side effects & Safety	Equity
1	**1.1 Goals setting (behaviour)**	Y	Y	Y	Y	Y	Y
2	**1.2 Problem solving**	Y	Y	Y	Y	Y	Y
3	**1.3 Goal setting (outcome)**	Y	Y	Y	Y	Y	Y
4	**1.4 Action planning**	Y	Y	Y	Y	Y	Y
5	**2.1 Monitoring of behaviour by others without feedback**	N	N	N	N	Y	Y
6	**2.2 Feedback on Behaviour**	Y	Y	Y	Y	Y	Y
7	**2.3 Self-monitoring of behaviour**	Y	Y	Y	Y	Y	Y
8	**2.5 Monitoring the outcome(s) of behaviour without feedback**	N	N	N	N	Y	Y
9	**2.7 Feedback on outcomes of the behaviour**	Y	Y	Y	Y	Y	Y
10	**3.1 Social support (unspecified)**	Y	Y	Y	Y	Y	Y
11	**3.2 Social support (practical)**	Y	Y	Y	Y	Y	Y
12	**4.1 Instruction on how to perform a behaviour**	Y	Y	Y	Y	Y	Y
13	**5.1 Information about health consequences**	Y	Y	Y	Y	Y	Y
14	5.2 Salience of consequences	Y	Y	Y	Y	Y	Y
15	**5.3 Information about social and environmental consequences**	Y	N	N	N	Y	Y
16	**6.1 Demonstration of the behaviour**	Y	Y	Y	Y	Y	Y
17	6.2 Social comparison/reminder of past success	Y	Y	Y	Y	Y	Y
18	**7.1 Prompts/cues**	Y	Y	Y	Y	Y	Y
19	**8.1 Behavioural practice / rehearsal**	Y	Y	Y	Y	Y	Y
20	**9.1 Credible source**	Y	Y	Y	Y	Y	?
21	10.2 Material reward	Y	Y	Y	Y	Y	Y
22	**11.5 Review of behaviour goals**	Y	Y	Y	Y	Y	Y
23	**11.7 Review outcome goals**	Y	Y	Y	Y	Y	Y
24	**12.1 Restructuring of the physical environment**	Y	Y	Y	Y	Y	Y
25	12.2 Restructuring the social environment	Y	Y	Y	Y	Y	Y
26	**12.5 Adding objects to the environment**	Y	Y	Y	Y	Y	Y

Y=yes, meets this APEASE criterion, N=no, does not meet this APEASE criterion.

Bolded BCTs are frequently used