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Uncertainty and decision-making in critical care: lessons from managing COVID-19 ARDS in preparation for the next pandemic

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ABSTRACT

Purpose Coronavirus disease 2019 (COVID-19) acute respiratory distress syndrome (ARDS) was an emergent syndrome that led to high volumes of critically ill ventilated patients. We explored influences on decision-making regarding management of COVID-19 ARDS mechanical ventilation to identify modifiable factors to improve preparedness for future pandemics.

Methods A systematic review and small group interviews informed the development of an international questionnaire (UK, Italy, Germany and Netherlands) on factors influencing COVID-19 ARDS ventilation decision-making in critical care professionals. Participants ranked four themes in order of importance: disease (uncertainties around COVID-19 ARDS), contextual (cognitive strain), environmental (structural logistics) and team factors. Participants also ranked the subthemes within each theme. Thematic analysis was used to derive findings from qualitative data. Kruskal-Wallis, Mann-Whitney U and Kendall's tau were used for quantitative data analysis.

Results Patient factors (comorbidities, clinical/biochemical parameters) were the most studied influences in the extant literature on decision-making; uncertainty was one of the least studied. 371 critical care professionals responded to the questionnaire. Disease uncertainty (lack of applicable guidelines, unfamiliarity with pathophysiology) was ranked as the most important influence on ventilation decision-making for COVID-19 ARDS across regions, professions and experience levels ($p<0.001$). Participants expressed underconfidence in their decision-making (median score: 9/20); this was unaffected by experience ($p=0.79$) or profession ($p=0.58$). Qualitative findings supported and extended the initial proposed influences, including the impact of team factors (+ve) and resource limitations (–ve) on disease uncertainty.

Conclusion Future pandemic preparedness programmes should target modifiable influences such as information sharing, teamworking and resource limitations to mitigate against the negative influence of uncertainty and thereby improve decision-making overall.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Coronavirus disease 2019 (COVID-19) patients with acute respiratory distress syndrome (ARDS) who died had a lower implementation of consensus-based ARDS therapies during their admission, but there are no empirical data on what may have influenced clinical decision-making and led to lower compliance with ARDS treatment modalities during the pandemic.

WHAT THIS STUDY ADDS

⇒ Disease uncertainty (lack of applicable guidelines and unfamiliarity with pathophysiology) was the most important influence on ventilation decision-making for COVID-19 ARDS reported by critical care clinicians, across European regions, professions and experience levels. Other, more modifiable influences were also reported, such as effective information sharing, teamworking and resource management.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Disease uncertainty will remain a complicating factor in the decision-making regarding any novel pathogen that leads to critical illness. Future pandemic preparedness programmes should target these more modifiable influences to mitigate against the negative influence of uncertainty, improving decision-making and treatment provision overall.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic led to intensive care units (ICU) being placed under pressure to manage large volumes of patients with COVID-19 ARDS requiring invasive mechanical ventilation. Multicentre studies from Europe and the UK also reported increased ICU mortality (24.4% and 38.8%, respectively).[1] Consensus-based acute respiratory distress syndrome (ARDS) therapies (eg, prone position, neuromuscular

blockade) are implemented at a certain disease severity, and their delivery is time-sensitive. Real-world compliance with evidence-based ARDS management strategies is difficult at a system level, particularly during times of workforce stress, such as a pandemic.[2] To understand this in more detail, several studies across Europe have explored the care and outcomes of patients with COVID-19 ARDS.[3–5] While clinical data were comparable to similar European studies, analysis from the UK study highlighted a striking fact that patients who died had a lower implementation of ARDS therapies at any stage of admission, despite the identification of opportunities compared with patients who died in Europe.[3] It has been suggested that ICU bed capacity (the UK has one of the lowest ICU beds/capita in Europe), was a potential driver of this difference.[6] There is, however, no concurrent empirical data on what influenced clinical decision-making and this lower compliance with ARDS treatment modalities during the pandemic.

Clinical decision-making is a complex cognitive process, and decisions in critical care are often time-pressured, dynamic and high-stakes and can be fraught with the potential for bias.[7] Uncertainty is also a pervasive issue in medical decision-making, and most intensivists will have their own cognitive strategies for handling uncertainty.[8 9] The pandemic placed additional strain on many aspects of critical care decision-making, and uncertainty around optimal treatment was a particular challenge. The highly-emergent evidence base during the pandemic was often contradictory, and clinicians were handling these conflicting opinions within a context that was stressful both in and outside of work. Thus, the three major domains of uncertainty, probability, ambiguity and complexity were all in flux, presenting major challenges to medical decision-making. Furthermore, there is a limited body of research on what influences critical care clinicians' decision-making regarding the initiation, titration and cessation of interventions,[10] with the extant literature primarily focusing on specific decision-making scenarios, such as admitting decisions and end-of-life decision-making. There has been much discussion about what lessons we can learn from COVID-19 for the next pandemic.[6 11 12] An ex-post exploration of the influences on deviation from or adherence to consensus-based ARDS treatments for COVID-19 patients with ARDS presents us with a unique opportunity to gain insight into influences on clinical decision-making during pandemic conditions.[3–5]

Our study aimed to (1) explore the influences on ventilation decision-making for COVID-19 ARDS, specifically focusing on the use or non-use of consensus-based ARDS treatment modalities (2) identify if these influences differed across various European critical care professionals and (3) explore the relationship between these influences and ventilation decision-making during COVID-19.

METHODS

This was a mixed-methods study, with two main research components: a systematic review of the literature, and an internationally administered online questionnaire, collecting both qualitative and quantitative data. Ethical approvals were obtained in the UK from the Health Research Authority (HRA) (IRAS: 315805), and permissions or waivers were granted from relevant bodies in other participating countries (see Ethics approval section below for all details). A preprint of this work is available online.[13]

Data collection

Systematic review

We conducted a systematic review to summarise the existing literature on decision-making regarding the commencement, titrating of and de-escalating of critical care interventions, including ventilation, inotropes and renal replacement therapies. We reviewed literature from the period January 2002 to January 2022 in PubMed, Embase, CINAHL, following the Preferred Items for Systematic Reviews and Meta-Analyses reporting guidelines and prospectively registered the review on PROSPERO (CRD42021283290). Further details of the search terms are available in the online supplemental information.

Questionnaire

We found no validated and relevant questionnaire instrument from our systematic review nor from wider (informal) searches of more generic clinical decision-making research. A questionnaire was thus developed to answer our study question. Development was guided by thematic concepts derived from (1) our systematic review and (2) analysis of small group semi-structured interviews conducted to qualitatively explore influences on decision-making in managing COVID-19 ARDS ventilation. These took place as a separate service evaluation of COVID-19 care. Participants were purposively selected based on the following criteria: sex, profession (nurse/doctor), years of experience in critical care. In total, 11 clinicians were interviewed (7 critical care physicians and 4 critical care nurses). Full details of these are available in the online supplemental information and online supplemental table S2. Questionnaire items were then discussed and developed using an iterative process by researchers with expertise in dynamic decision-making (MO) and critical care (ZP, JRP, TS). The questionnaire was pretested locally and then piloted with 10 participants representative of target professional groups. Feedback only led to minor formatting and layout changes to the questionnaire and we therefore included all pilot data in the final data set.

On the first page of the questionnaire, participants were asked to read the participant information sheet that summarised the study and confirm their understanding and consent to participate in the study. The questionnaire

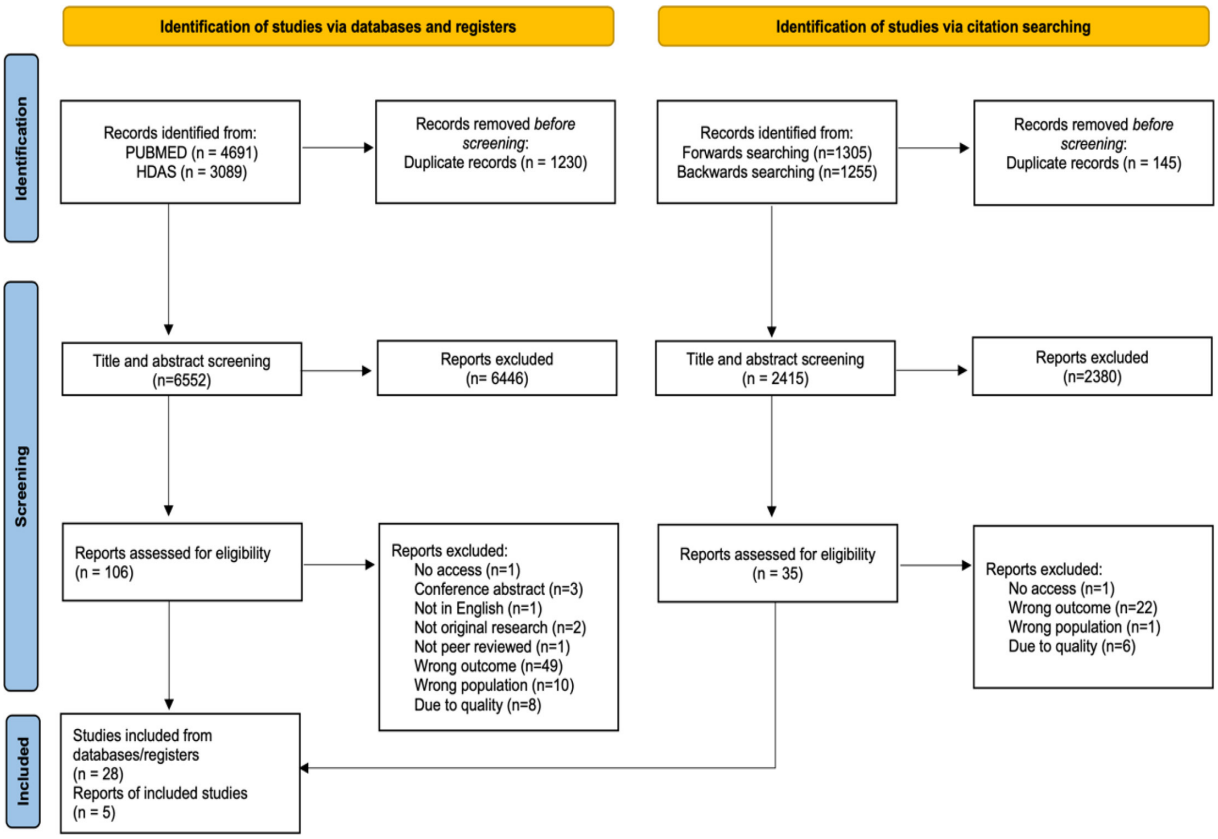

Figure 1 Preferred Items for Systematic Reviews and Meta-Analyses flow diagram for the systematic review.

was anonymous but we collected basic demographic information (gender, profession, seniority and country of work during the pandemic). Participants were then asked to rate their agreement on a 10-point Likert scale to a series of eight statements. The first three related to the participant's recalled degree of certainty in relating COVID-19 ARDS presentation to previous knowledge/experience of ARDS. The following three related to their recalled need for deviation from usual clinical practice in treating COVID-19 ARDS. The final two related to their confidence in managing COVID-19 patients with ARDS.

Subsequently, participants were asked to rank the influences of four high-level themes in managing COVID-19 ARDS ventilation: disease factors (primarily the uncertainties around the pathophysiology of COVID-19 and COVID-19 ARDS), contextual factors (primarily the cognitive strain of working in a pandemic), team factors (both as a positive and negative influence of decision-making) and environmental factors (the structural logistics that influenced decision-making). Participants were also asked to rank subthemes within each high-level theme. Free-text responses were invited at each section of the questionnaire for participants to add their own qualitative experience of decision-making during the pandemic.

SmartSurvey (https://www.smartsurvey.co.uk/) was used to create the survey and record the data. The data collected via SmartSurvey was encrypted, and stored on UK-based (General Data Protection Regulation) GDPR compliant servers. Downloaded data was stored on secure Barts Health NHS Trust servers in line with our UK HRA approved protocol and only accessible to the authors. A version of the full questionnaire is available in the online supplemental information. The questionnaire was translated into German, Dutch and Italian by the researchers SJS/PN, DvdB and AS, respectively. The questions, format and analysis of the questionnaire remained consistent across all versions. The order of the questions remained consistent between participants, but the order of the themes/subthemes to be ranked in sections 12–16 was randomised. All questions within a section had to be answered to move onto the subsequent question.

Questionnaire administration

The questionnaire was then disseminated across the UK between 27 July 2022 and 7 November 2022, and across Germany, Italy and the Netherlands between 18 October 2022 and 11 April 2023. Recruitment occurred through national critical care and professional societies and through the personal networks of the investigators. There were no incentives for clinicians to take part in the survey. The survey could only be completed once per device and the results were reviewed to ensure there were no duplicate entries.

As the construction of the questionnaire was dependent on the completion of both the systematic review and the semi-structured interviews, there was a time lag between the two waves of the pandemic and the questionnaire

Table 1 Themes and subthemes developed from the systematic review

Main theme	Subtheme	Description
Individual	Clinician's experience	Experience alters a clinician's approach to assimilating and processing clinical information. Those with more experience are more adept at using cues/abstract information and use heuristics/pattern recognition.
	Professional and personal risk	The perception of professional/personal risk negatively impacts a clinician's decision-making (eg, clinicians may choose to spread risk and/or practise defensive medicine).
	Uncertainty	The perception of uncertainty negatively impacts clinical decision-making. Clinicians may, for example, "freeze" and ultimately delay decision-making.
	Characteristics of the clinician	Characteristics of the clinician such as personality, education, age, specialty and gender often influence their decision-making.
Team	Support	Senior support and formal education optimise clinical decision-making. They help clinicians (especially those who are inexperienced) respond earlier and more appropriately, and give credibility to their decision-making.
	Dependence on colleagues	Communication and prior decisions made by colleagues impact subsequent clinical decisions (often negatively). Non-timely extubations, for example, may lead to increased use of physical restraints or increased sedation time.
	Team hierarchy	Rigid hierarchies can lead to clinicians at the bottom of the hierarchy having less autonomy for their decision-making, whereas collaborative teams increase it.
System	Evidence/guidelines/protocols	Protocols and guidelines help clinical decision-making in certain situations by reducing variability and uncertainty. However, they are often rigid and not customisable to the specific decision.
	Time/workload	Workload and time constraints influence the practicalities of certain decisions. Sedation delays may occur, for example, for pragmatic reasons rather than clinical ones.
	Hospital structure	The set-up of the critical care unit (size, bed space), budgetary constraints and pressure from management also influence the practicalities of certain decisions.
Disease	Clinical condition	The patient's clinical condition (comorbidities, observations, biomarkers) influences the clinical scenario and thereby the clinician's decision-making. It is often the most important factor. There is also pressure from families and consideration of equity.

administration. We acknowledge the risk of recall bias due to this time lag, but this had to be balanced with ensuring the creation of a high-quality questionnaire that addressed our research question. Further, there is evidence from the psychological literature that memories associated with strong emotions are much more accurately recalled, potentially reducing the recall bias issue in this instance.[14]

Analysis

Systematic review

A convergent integrated approach allowed all included studies (quantitative, qualitative, mixed method) to be synthesised together.[15] Coding and categorising were done by three researchers (HM, KM and TS). A meta-synthesis was then conducted from this data to develop relevant themes and subthemes.[16 17]

Questionnaire data: quantitative data

A Kendall's tau (a non-parametric measure of the strength and direction of association that exists between two variables measured on an ordinal scale) was conducted to assess the strength of association between the three scores from the statements assessing participants' certainty in relating COVID-19 ARDS presentation to previous knowledge/experience. If there was a significant ($p<0.05$) and at least moderate strength of association ($\tau>0.21$), then the scores were aggregated.[18] The test was also conducted for the three scores from the statements assessing participants' recalled need for deviation from usual practice.

A Kruskal-Wallis test was conducted to determine that the distribution of the themes/subthemes was not random. A Mann-Whitney-Wilcoxon test was conducted to assess the relationship between the participants' characteristics on assessment of COVID-19 ARDS, confidence

Table 2 Demographic of questionnaire participants from UK, Italy, Germany and Netherlands

	All (N=371)
Age (range)	41 (23–66)
Gender	
Male	179 (48%)
Female	187 (50%)
Profession	
Doctor	177 (48%)
Nurse	152 (41%)
Physio/respiratory therapist	42 (11%)
ICU experience	
0–4 years	123 (33%)
5–9 years	64 (17%)
10+years	184 (50%)
Experience of non-COVID-19 ARDS	
A lot	183 (49%)
Some	123 (33%)
Only a little	36 (10%)
None	29 (8%)
Knowledge of national ARDS guidelines prior to 2020	
Aware and knew the content	240 (65%)
Aware but did not know the content	93 (25%)
Was not sure they existed	33 (9%)
Adherence to national ARDS guidelines prior to 2020	
Adherent	235 (63%)
Rarely or somewhat adherent	78 (21%)
Never adherent	46 (12%)

ARDS, acute respiratory distress syndrome; COVID-19, coronavirus disease 2019; ICU, intensive care unit.

in their decisions/knowledge and perceived influences on decision-making.

Questionnaire data: qualitative data

The ranking of the existing qualitative themes and subthemes presented in the questionnaire was done using a simple weighted rank scale, with the maximum and minimum weight determined by the number of answer choices. For the free-text responses, inductive content analysis was used to add context to existing themes, identify new themes and explore reasons for variability between participants' responses. Initial coding was undertaken by three researchers (KM, WT and TS) independently. Codes were discussed, agreed and refined in several data meetings before being applied to the remaining responses. Subthemes and themes were developed and agreed at further data meetings and then presented to coauthors for discussion and refinement.[19 20]

Finally, researchers (KM, TS, JRP, ZP, MO) convened a data meeting and discussed and synthesised data from the systematic review and the questionnaire to create a higher-order synthesis and interpretation of decision-making influences, comparing themes from the extant literature with the new emergent themes.[21] To visualise the strength of relationships between responses within each theme, a network analysis was created to illustrate the relationships between top-ranked influences on decision-making within each theme. Each individual response within the four themes was assigned as a network node, and edges placed between nodes linked the top-ranked choices within each theme for each individual. The network was then plotted where node size is log-portioned to a number of top choices overall and edge weight log-proportional to a number of individual top-ranking both choices. R packages *igraph* and *tidygraph* were used to generate and visualise the networks.[22 23]

The analysis of the questionnaire data only included complete responses.

RESULTS

Systematic review

8967 papers were identified via databases and citation searching. After title and abstract screening, 141 studies progressed to full-text review. Of the 141 studies, 33 were deemed eligible for inclusion (figure 1). 21 out of 33 studies investigated decision-making in nurses exclusively (online supplemental table S1). Thematic analysis led to the generation of 11 subthemes, situated within four broader high-level themes: human, team, system and disease factors. The disease factor related to the patient's clinical condition (comorbidities, observations, biochemistry) was the most common theme (20 of 33 studies) (table 1). A full report of the systematic review is published elsewhere.[24]

Online questionnaire

There were 371 complete responses from healthcare professionals with varying experience levels (table 2). There were 254 incomplete responses; assuming that there was no overlap between incomplete and complete responses, the completion rate was 59%. It is difficult to estimate the response rate as the questionnaire was widely disseminated and therefore the number of potential participants that viewed our questionnaire is not clear. Data from incomplete responses and responses per country are reported in the supplemental information (online supplemental table tables S4–S8).

The three statements exploring the recalled degree of certainty in relating COVID-19 ARDS presentation to previous knowledge/experience of ARDS in general was well-correlated (τ 0.39–0.55). This was also true for statements exploring the recalled need for deviation from usual clinical practice in treating COVID-19 ARDS (τ 0.32–0.55). Therefore, these were collapsed into two aggregate scores from 3 to 30, respectively, representing the participant's assessment of the similarity of COVID-19 ARDS to previous knowledge/experience (certainty

Table 3 Median scores on participants' perception of COVID-19 ARDS presentation, management and confidence in decision-making (minimum score: 3, maximum score: 30)

Theme	Questions asked	All	N	D	P	<5 years	≥5 years
Certainty	Total Certainty Score	**12 (8–17)**	**11 (7–16)**	**13 (9–17)**	**15 (9–17)**	**13 (9–17)**	**12 (8–17)**
	Patients were presenting in ways that were consistent with my previous knowledge/ experience of non-COVID-19 ARDS	4 (3–6)	4 (2–6)	4 (3–6)	5 (3–6)	4 (3–6)	4 (3–6)
	The disease course was similar to my previous experience/knowledge of other viral pneumonia	3 (2–5)	3 (1–5)	3 (2–5)	4 (2–6)	3 (2–5)	3 (2–5)
	The existing guidelines/protocols for managing non-COVID 19 ARDS were applicable to this situation	5 (3–7)	4 (2–6)	5 (3–7)	5 (3–7)	5 (3–6)	5 (3–7)
Deviation	Total Deviation Score	**20 (16–24)**	**22*** (18–25)**	**18*** (12–22)**	**21*** (18–24)**	**20 (16–23)**	**20 (15–24)**
	Patients were presenting in ways that required more deviation from the ARDS management guidelines compared with my usual practice of non-COVID-19 ARDS	7 (5–8)	8 (6–9)	7 (4–8)	7 (5–8)	7 (5–8)	7 (5–9)
	Patients were presenting in ways that meant using non-standard ventilatory strategies were necessary	7 (5–9)	8 (6–9)	6 (3–8)	8 (6–8)	7 (5.5–8)	7 (4–9)
	Patients were presenting in ways that meant using non-standard ventilatory strategies could improve patient outcome	6 (4–8)	7 (5–9)	5 (3–7)	7 (5–8)	6 (4–8)	6 (3–8)
Confidence	Pooled confidence	**9 (5–13)**	**8 (5–12)**	**9 (5–14)**	**11 (8–13)**	**9 (5–12)**	**8.5 (5–14)**
	I was confident that I had sufficient knowledge/ experience to treat COVID-19 ARDS	4 (2–7)	3 (2–6)	4 (2–7)	5 (3–7)	4 (2–6)	4 (2–7)
	I was confident that my ventilatory strategy for COVID-19 ARDS would improve patient outcome	5 (3–7)	4 (3–6)	5 (2–7)	6 (4–7)	5 (3–6.5)	5 (3–7)

Higher scores suggest higher certainty in relating COVID-19 ARDS presentation to previous knowledge/experience, higher recalled need for deviation from usual clinical practice and higher confidence in managing COVID-19 ARDS, respectively. The IQRs are included in parentheses. The aggregated presentation, management and confidence scores are in bold. Scores across all participants are shown followed by rankings across different professions—nurse (N), doctors (D), physios and respiratory care therapists (P); different experiences—<5 and ≥5 years of ICU experience. (***p<0.001).
ARDS, acute respiratory distress syndrome; COVID-19, coronavirus disease 2019; ICU, intensive care unit.

score, higher scores indicate more certainty) and of recalled need for deviation from usual clinical practice (deviation score, higher scores indicate greater need for deviation).

The median certainty score was 12 out of 30 (IQR: 8–17), and the median deviation score was 20 out of 30 (IQR: 16–24). The certainty score was not significantly correlated with the profession (doctor/non-doctor, p=0.082) or ICU clinical experience (5 or more years of ICU experience, p=0.408). The deviation score was lower in doctors (p<0.001 median 18 vs 22/30), but the deviation score did not correlate with ICU clinical experience (p=0.910; table 3).

Overall, participants reported low levels of confidence in their decision-making around COVID-19 ventilatory management (median score: 9/20, IQR: 5–13). Recalled confidence was unaffected by profession (p=0.786) or ICU experience (p=0.574). However, those participants who had a certainty score higher than the median reported greater confidence (p<0.001, median confidence 12 vs 6/20). However, the participants' deviation scores were not associated with the recalled confidence level in decision-making (p=0.163; table 3).

Participants ranked the order of the influences on their ventilatory decision-making as disease factors, followed by the team, then contextual and then environmental factors (p<0.001; table 4). Disease factor was seen as the most important influence across regions, professions and experience levels. Participants ranked unfamiliarity with COVID-19 pathophysiology (disease), strong teamwork/ spirit (team), limited human and physical resources (contextual) and ward layout/patient location (environment) as the most important subthemes within their respective themes.

Table 4 Ranking of themes and subthemes (scores nearer to 1 are ranked more important)

Themes	Subthemes	All	N	D	P	<5 years	≥5 years
Disease		**1.87**	**1.97**	**1.82**	**1.71**	**1.94**	**1.83**
	Unfamiliarity with COVID-19 pathophysiology	1.86	1.78	1.87	2.07	1.75	1.91
	Previous guidelines did not fit	2.35	2.49	2.28	2.10	2.50	2.27
	Lack of consensus around ventilation	2.81	2.89	2.68	3.10	2.85	2.80
	Fear of active decisions	2.98	2.84	3.16	2.74	2.91	3.02
Team		**2.30**	**2.17**	**2.38**	**2.43**	**2.26**	**2.32**
	Strong team work/spirit	2.23	2.13	2.37	2.02	2.34	2.18
	Team-based decision-making	2.56	2.55	2.62	2.38	2.30	2.69
	Discussing with colleagues	2.73	2.97	2.42	3.12	2.85	2.67
	Experience of team members	3.05	3.09	3.01	3.10	3.24	2.96
	Poor training on ARDS net guidance	4.43	4.26	4.58	4.38	4.28	4.50
Contextual		**2.73**	**2.82**	**2.63**	**2.81**	**2.73**	**2.73**
	Limited human and physical resources	2.06	2.14	1.99	2.02	2.08	2.04
	Clinical impotence	2.16	2.11	2.22	2.12	2.24	2.13
	Cognitive overload	2.80	2.73	2.82	2.95	2.73	2.83
	Desensitisation of acuity of patients	2.98	3.01	2.97	2.91	2.95	3.00
Environment		**3.11**	**3.05**	**3.17**	**3.05**	**3.07**	**3.13**
	Ward layout/patient location	1.75	1.83	1.71	1.64	1.80	1.72
	Working patterns	1.81	1.85	1.75	1.88	1.81	1.80
	Unfamiliarity with different ventilators	2.44	2.32	2.55	2.48	2.38	2.48

In bold are the ranks of the themes, and underneath, there is the ranking of subthemes within that theme. Rankings across all participants are shown, followed by rankings across different professions—nurse (N), doctors (D), physios (P); different experiences—<5 and ≥5 years of ICU experience; and different regions (UK and EU).
ARDS, acute respiratory distress syndrome; COVID-19, coronavirus disease 2019; EU, European Union; ICU, intensive care unit.

Qualitative free-text analysis

There were 268 free-text responses from 108 participants. This led to 302 codes, with the majority relating to disease factors. Nine participants expressed disagreement with the themes/subthemes presented and stated that these did not reflect their experience.

Eleven subthemes were developed from the free-text analysis. Three subthemes related to participants' uncertainty in managing COVID-19 ARDS ventilation: COVID-19 ARDS as a novel syndrome, information sharing and experience/evidence. Depending on the context, these increased or decreased disease uncertainty (figure 2).

Eight further subthemes were identified. Three were contextual factors: the emotional response to COVID-19 working, logistical/organisational difficulties such as managing increased bed spaces and physical exertion. Four were team factors: communication difficulties while wearing personal protective equipment (PPE, conflict within and between teams, pressure to conform to consensus and team composition (outside of team members' experience, eg, unfamiliarity with staff and senior support). One related to individual characteristics (level of confidence, use of intuition). Of these, the team composition was the most frequently coded (online supplemental table S3).

Synthesis and interpretation of data

The themes and subthemes developed from the systematic review and online questionnaire could be split into those that affected the clinical scenario and those that affected an individual clinician's decision-making ability. The final decision made by a critical care clinician is dependent on both elements. Research prior to 2022 mostly focused on factors that influenced the clinical scenario (figure 3a), which included system factors such as time and workload, existing protocols/evidence and critical care environment (eg, hospital layout); team factors such as prior decisions made by colleagues; and most importantly disease factors relating to the patient's clinical condition (clinical parameters, comorbidities). The individual factor, particularly a clinician's experience, was the main influence on an individual clinician's decision-making ability, along with team factors such as senior support and team hierarchy.

In comparison, there were many more influences on an individual clinician's decision-making ability during the pandemic (figure 3b). The greatest influence was

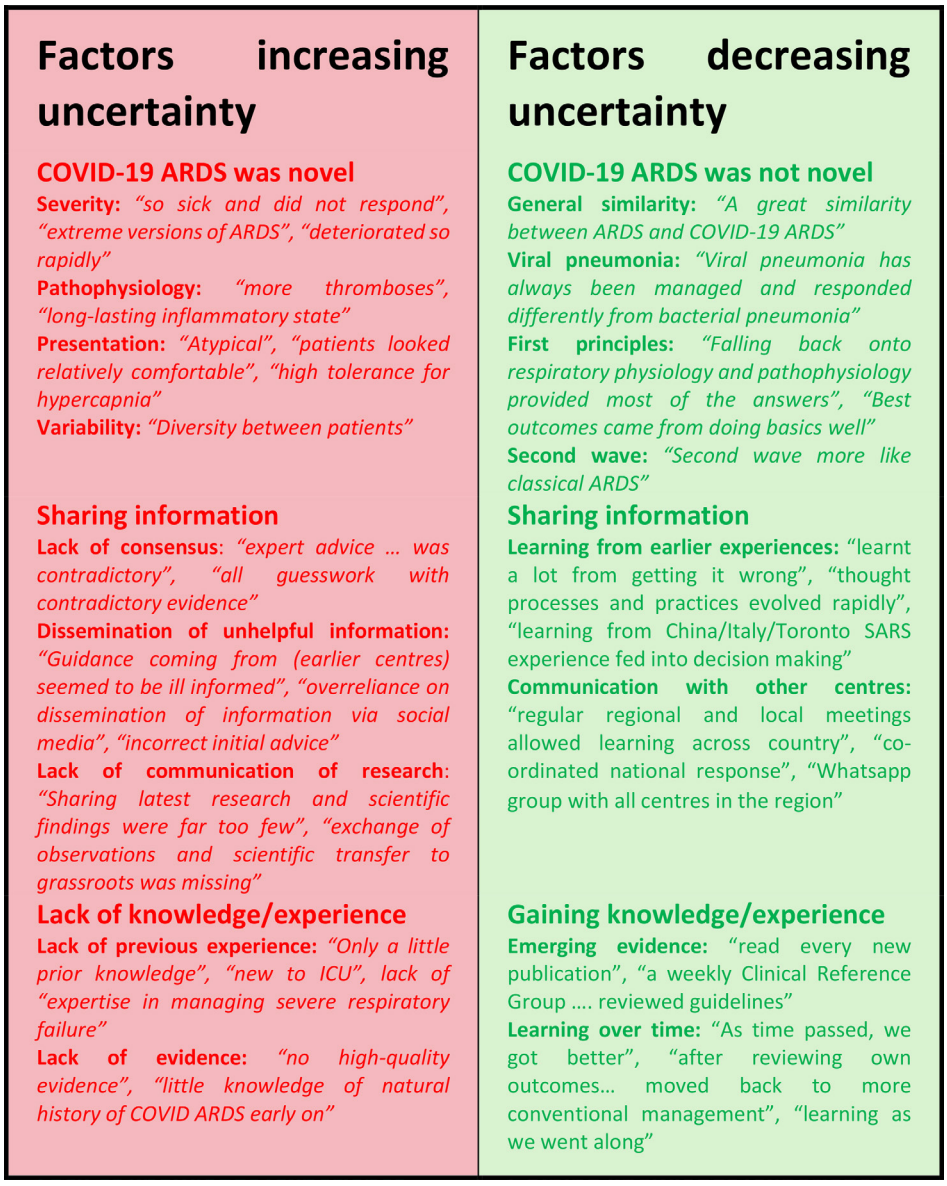

Figure 2 Factors identified to increase and decrease uncertainty in decision-making from the free texts. Indicative quotes have been used to highlight these points. ARDS, acute respiratory distress syndrome; ICU, intensive care unit.

disease uncertainty, but contextual stress and positive team factors (team spirit, collaborative decision-making) were also new but important influences on decision-making. The lack of existing protocols/evidence also impacted disease uncertainty. Finally, individual factors such as experience and profession appeared to be less of an influence on the clinician's decision-making ability.

Network analysis

A network analysis to illustrate the relationship between influences and their relative importance within individuals was generated (figure 4). The strongest and most commonly co-expressed influences were: (1) uncertain pathophysiology, (2) limited resources and (3) physical barriers. Strong teamwork was the most commonly identified mitigating factor.

DISCUSSION

In this large international, interprofessional study of over 350 critical care professionals, we identified influences on ventilation decision-making for COVID-19 ARDS. Given the data on differences in the delivery of consensus-based ARDS treatments between the UK and European centres we expected to find differences in responses across our cohort but did not. Disease uncertainty was the key influence, ranked as the most important across all regions, professions and experience levels and supported by further uncertainty-related themes arising from the free-text analysis. Participants reported feeling under-confident in their decision-making for COVID-19 ARDS. Confidence was associated with certainty around whether COVID-19 ARDS was similar to clinicians' previous experience and/or knowledge of ARDS. Despite the central

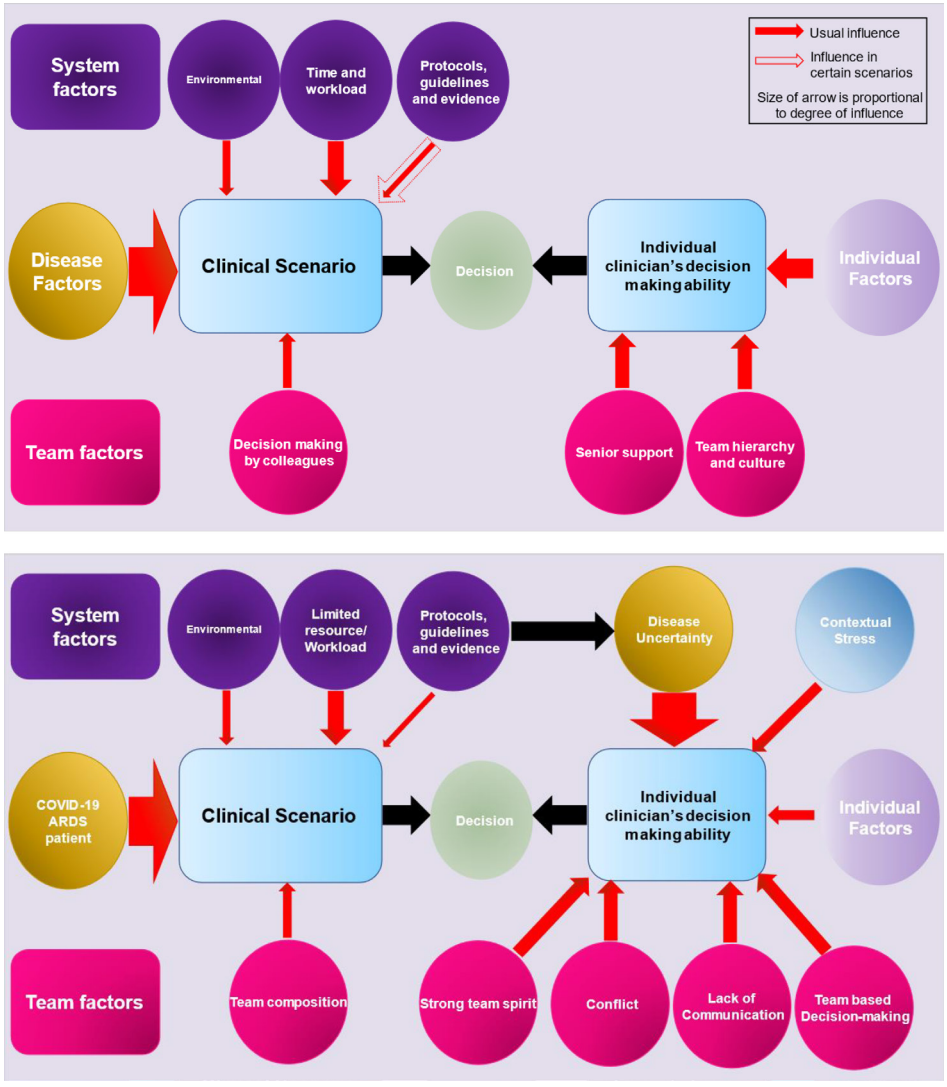

Figure 3 Comparison of key themes related to clinical decision-making from (1) systematic review and (2) empirical data from the current study.

role that uncertainty played in decision-making during the pandemic and within clinical decision-making generally, our systematic review findings indicate it is an understudied area, especially for critical care physicians and interprofessional team decisions. The systematic review also showed that few studies explored the influences on an individual clinician's decision-making ability, and the most explored theme, individual factors, appeared to have less influence on COVID-19 ARDS decision-making. Lastly, the finding of modifiable influences such as team, environmental and resource factors on decision uncertainty offers a blueprint for additional components of pandemic preparation educational programmes for healthcare professionals.

Somewhat after the event, there is now substantial consensus that standard ARDS treatments are also effective for COVID-19 ARDS.[25] Our data suggests that consensus was not present during the pandemic, contributing to uncertainty surrounding ventilatory management. Disease uncertainty is also not unique to the COVID-19 pandemic; a recent systematic review on influenza pandemic guidelines found weak consensus on treatment options.[26] Optimising sharing of evidence-based information is a means to reduce this disease uncertainty yet proved challenging during COVID-19.[27] A 'living guideline' framework is an implementable policy, that is, worth exploring to maintain and frequently update high-quality, reputable clinical management guidelines (for both treatment and support care) for high-risk pathogens such as coronaviruses and influenzas.[26] However, given that a degree of disease uncertainty during a pandemic appears inevitable, other modifiable influences on decision-making may be important foci to improve the overall decision-making context.

Team factors, for example, are an important and leverageable positive influence on decision-making, which we found to be understudied in our review of the literature. In general, meta-analyses of team-training interventions indicate a positive impact on team performance, including decision-making, both in healthcare and in

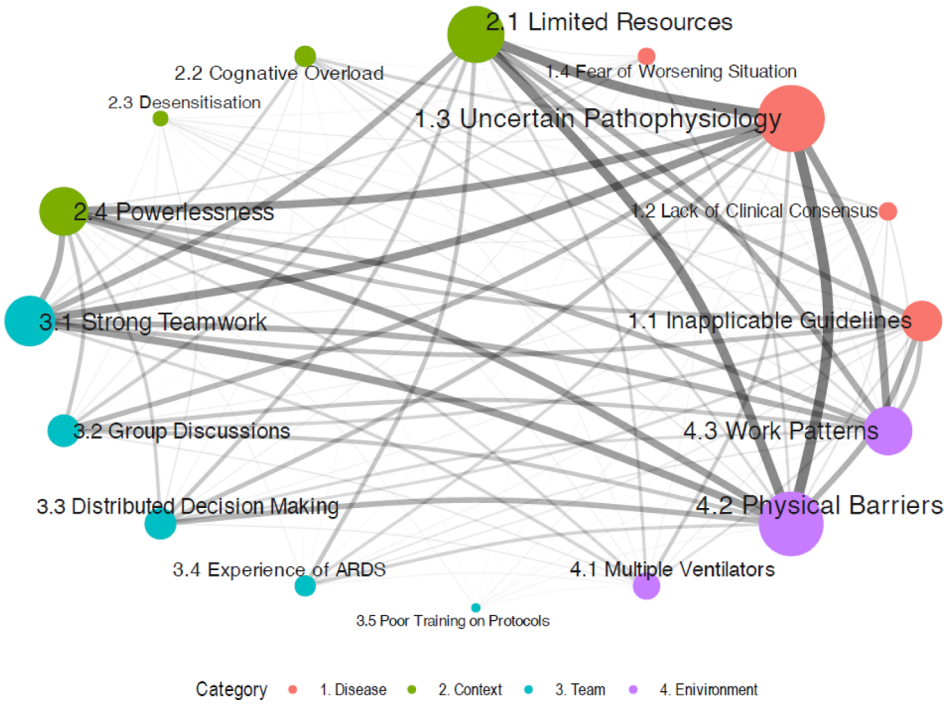

Figure 4 A network analysis illustrating the relationship between the relative importance of subthemes within each overall theme (disease—red, contextual—green, team—blue, environment—purple). Overall, a pattern of Uncertain Pathophysiology, Limited Resources and Physical Barriers represent a shared set of themes across respondents. Strong teamwork was the most commonly identified mitigating factor. ARDS, acute respiratory distress syndrome.

other industries.[28] Given the success of the WHO/European Society of Intensive Care Medicine (ESICM) C19 SPACE training programme on preparing clinicians for pandemic-related work,[29] we suggest consideration of adding a specific, practical team-training element to this.

Our study also highlighted the importance of considering the unique context in which clinicians had to make decisions during the pandemic (contextual factors). Limited resources may be a key barrier to address early on in any future pandemic to improve decision-making. The need for more critical care beds is not new, but COVID-19 has offered an acute lens through which to view this issue.[6] While the influence of limited critical care capacity on triage/admitting decision-making (including ethical implications) is obvious,[30] it is less clear for decision-making for patients already on the ICU and specifically ventilation therapy decisions. A small body of research exists that explores how healthcare environments, including resources such as equipment and disposable items, enabled and constrained modes of care during the pandemic, although none focused specifically on decision-making.[31] However, the link between distraction and decreased decisional ability is well established[32–34]; it may be that the stressors related to resource limitations in general created a suboptimal context for decision-making. Again, the WHO/ESICM C19 SPACE training is an ideal platform to add a module for hospital logisticians and administrators to enhance performance in the vital role of pandemic preparedness. Innovative solutions, such as triaging and transferring patients between hospitals within an existing critical care network, could also be used to maximise limited resources.[35]

Further, the physical barriers from the nature of the critical care unit set-up had the strongest environmental influence on decision-making and had a possible link with limited resources. This intuitively makes sense as units had to comply with infection control measures in the constraints of the existing set-up. However, such environmental stressors were also present in previous pandemics, such as the H1N1 pandemic, stressing the need to learn from these issues for future pandemics.[36] Human-centred design approaches could use the existing knowledge of clinicians from the COVID-19 pandemic and involve them in the development of future pandemic-proof critical care units to reduce challenges encountered from limited resources.[37]

Finally, the need to support the mental and physical well-being of critical care professionals, in and outside of pandemic conditions, is now irrefutably established.[38–41] Beyond the moral and humanitarian aspects of this, our findings emphasised the cognitive strain that clinicians experienced during the pandemic, in the form of clinical impotence and cognitive overload and the possible link between working patterns, feelings of powerlessness and disease uncertainty. This finding not only makes intuitive sense but also fits with a human factors perspective on patient safety and error minimisation.[42]

Strengths and limitations

Our study has several strengths. This data was derived from a diverse set of healthcare professions working in ICUs across four regions (UK, Germany, Italy and the Netherlands). The results across professions, experience levels and regions were broadly similar, suggesting data validity. Multiple investigators with different backgrounds were involved in developing the methodology and the higher-order analysis. Further, all data analysis was conducted by at least two researchers, and an iterative process was used.

There are also limitations. As with all questionnaires, there is a degree of sampling and non-response bias. Sampling bias was reduced by disseminating the questionnaire via several routes, including professional societies and a diverse set of professional networks. Non-response bias was reduced by sending reminders for questionnaire completion. The data on incomplete responses is included in the online supplemental file. We accept, however, that non-responders may have had different experiences, and it is possible that some relevant influences may be missing. Self-reported data may be subject to both recall and biases, such as those caused by the mental health effects on workers from pandemic working.[43] Participants' views on decision-making are post hoc and their views may have differed during the peak of the waves and between the waves. However, we did not see skews towards higher confidence in general, nor minimisation of the influence of uncertainty, which might be expected from hindsight bias and positivity recall bias.[44] This may be in part due to clinicians experiencing strong emotions during the COVID-19 pandemic, which is known to enhance recall.[14] While we cannot quantify the magnitude of potential biases, many respondents reported both positive and negative experiences and many reported frankly and eloquently in their free-text the challenges faced in decision-making and also what helped mitigate these. There may be response bias as participant responses were limited to the options available in the questionnaire. However, this is addressed by the inclusion of free-text answer options and we report the small numbers who expressed disagreement with the themes presented. Further, the available options in each question of the questionnaire were in a random order reducing order-effects bias.

CONCLUSION

We identified key influences on ventilation decision-making during the COVID-19 pandemic that appear consistent across professions and experience levels, in particular uncertainty around whether COVID-19 ARDS should or should not receive consensus-based ARDS therapies. Addressing disease uncertainty more effectively will be crucial in the next pandemic, but this will likely remain challenging. Future pandemic preparedness programmes might target more modifiable influences such as information sharing channels, teamwork training and resource limitations prevention to mitigate against the negative influence of uncertainty and thereby improve decision-making overall.

Patient and public involvement statement

This study focused on bedside decision-making in clinicians and its influences. Patients and/or the public were not involved in the design of the study, but members of the UK Royal College of Anaesthetists Patients, Care and Public Involvement and Engagement committee have agreed to support us in the writing of a plain English summary of this study for news and online media.

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Contributors TS and ZP conceived the study. TS, ZP, JRP, KM and MO were responsible for study design. JRP and KM were primarily responsible for quantitative data analysis. TS, KM, HM, WT and MO were primarily responsible for qualitative data analysis. JRP, ZP, MC, AS, BF, DvdB, MP, SJS and PN led the data collection process. All authors critically revised the content of the manuscript. All authors read and approved the final manuscript. TS is the guarantor of the study.

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