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Review

Stress and decision-making in resuscitation: A systematic review

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Abstract

Background: During resuscitation decisions are made frequently and based on limited information in a stressful environment.

Aim: This systematic review aimed to identify human factors affecting decision-making in challenging or stressful situations in resuscitation. The secondary aim was to identify methods of improving decision-making performance under stress.

Methods: The databases PubMed, EMBASE and The Cochrane Library were searched from their commencement to the 13th of April 2019. MeSH terms and key words were combined (Stress* OR "human factor") AND Decision. Articles were included if they involved decision makers in medicine where decisions were made under challenging circumstances, with a comparator group and an outcome measure relating to change in decision-making performance.

Results: 22,368 records in total were initially identified, from which 82 full text studies were reviewed and 16 finally included. The included studies ranged from 1995 to 2018 and included a total of 570 participants. The studies were conducted in several different countries and settings, with participants of varying experience and backgrounds. Of the 16 studies, 5 were randomised controlled trials, 3 of which were deemed to have a high risk of bias. The stressors identified were (i) illness severity (ii) socio-evaluative, (iii) noise, (iv) fatigue. The mitigators identified were (i) cognitive aids including checklists, (ii) stress management training and (iii) meditation.

Conclusions: Human factors contributing to decision-making during resuscitation are identified and can be mitigated by tailored stress training and cognitive aids. Understanding these factors may have implications for clinician education and the development of decision-support tools.

Introduction

During the resuscitation of an injured or critically unwell patient, decisions are made frequently and can affect the morbidity and mortality outcomes for that patient.[1] The resuscitation environment can also be stressful and important decisions need to be made with limited information about the underlying causes of the deranged physiology and often within short time frames.

'Human factors' (HFs) is a term used to describe the science of optimising human performance through the study of the interrelationships between humans, the tools they use, and the environment in which they work.[2]

HFs is an established scientific discipline originally focused on other safety critical industries such as aviation and engineering.[3] Applying HFs concepts to healthcare has been an increasingly important component of contemporary safe medical practice and understanding the HFs that affect decision-making is important for a myriad of reasons. Teaching clinicians about how HFs affect decision-making may allow them to make better decisions during resuscitations. Decision support systems that take HFs into account are likely to be more effective in helping achieve optimal patient outcomes.[1]

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The aim of this systematic review was to identify the HFs that affect decision-making in challenging or stressful situations in resuscitation of critically unwell patients, with a secondary aim of identifying the most effective methods of *improving* decision-making performance.

Methods

Search strategy

This systematic review searched English language literature and reported according to the PRISMA guidelines.[4] Our broad question of interest was "What HFs contribute to decision making in challenging situations?" We used a combination of subject headings (/) and keywords (""). In order to allow a sensitive search strategy, we searched broadly, combining the terms: (Stress* OR "human factor") AND Decision.

Eligibility criteria

1 Population: Decision makers in medicine (doctors, paramedics, nurses) where decisions must be made under challenging circumstances (e.g. resuscitation of critically unwell or severely injured patients).
2 Exposure/Comparator: Variables that contribute to decision making.
3 Outcomes: Change in decision making performance, as defined by the individual study.
4 Study Designs: Randomised controlled trials, controlled trials and cross-sectional studies.

Articles were excluded if they (i) were in the wrong setting (e.g. oil refinery, air traffic control), (ii) had the wrong outcome measure (e.g. sporting performance rather than decision making), or (iii) were article types of high bias risk (i.e. case reports and case series, as well as editorials, letters and conference abstracts).

Information sources

We searched for articles from three databases (PubMed, EMBASE, and The Cochrane Library (Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials (CENTRAL)), extending from the databases' commencement to the 13th April 2019. We also screened reference lists of all selected studies for relevant articles that might not have been captured by the search strategy listed above. Protocol for the review was published on PROSPERO, the International prospective register for systematic (PROSPERO registration number CRD42019122157).

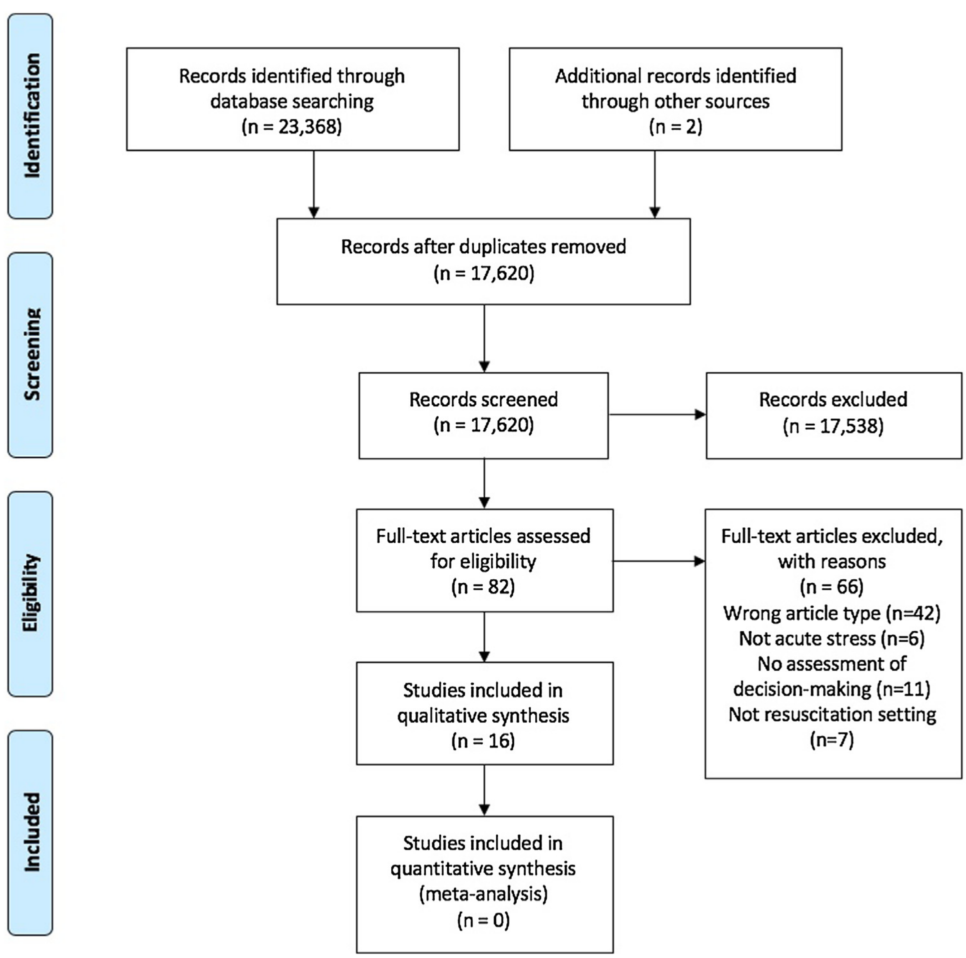

Fig. 1 – PRISMA flow chart of study selection.

Table 1 – Study characteristics.

Study	Year	Country	Participants	Study population (n)	Age Mean (SD) or range	Years experience Average/range
Anderson et al.[6]	1995	USA	Residents doctors	46	NA	NA
Arul et al.[7]	2015	Afghanistan	Staff members at Camp Bastion	115	NA	NA
Castro and de Almondes [8]	2018	Brazil	Mobile emergency care services physicians	26	35.2 (7.6)	<6y (n = 13), 6-10y (n = 7), >10y (n = 6)
Doleman et al.[9]	2016	UK	Consultant Anaesthetists	8	42 (4.7)	14 (5.6)
Flin et al.[10]	2013	UK	Anaesthetists involved in airway incidents reported to NAP4	12	NA	NA
Flinn and Armstrong [11]	2011	Ireland	Junior doctors	30	23–30	NA
Folscher et al. [12]	2014	South Africa	ED doctors	41	NA	NA
Hardy et al. [13]	2017	France	Anaesthetists	24	NA	4–33
Harvey et al.[14]	2012	Canada	Emergency medicine and general surgery residents	13	NA	PGY 1 to 4
Kelm et al.[15]	2018	USA	Interprofessional code team members	24	NA	Median 4.3 (IQR 2.1, 12.3)
Krage et al.[16]	2017	Netherlands	Anaesthetists and trainees	30	34.8 (6.1)	NA
Marshall and Mehra [17]	2013	Australia	Critical Care Doctors attending an airway course	64	NA	14.0 (1.0–37.5) in control group. 9.8 (0.5–35.0) in intervention group
McClelland et al.[18]	2013	USA	Nurses	65	35 (10)	7.7
Pietsch et al.[19]	2016	Germany	HEMS crew members	40	NA	NA
Schnittker et al.[20]	2018	Australia	Anaesthesia staff (12 consultants + 4 nurses)	16	NA	10 of 16, with > 15 years experience
Wetzel et al.[21]	2011	UK	Resident Surgeons	16	32.8 (2.4)	6.7 (2.3)

Caption: NA = Not available; UK = United Kingdom; HEMS = Helicopter Emergency Medical Services; ED = Emergency Department; NHS = National Health Service.

Study selection

Following the search, duplicates were removed (using Covidence) and titles were screened by one author (CG). The abstracts of the identified studies were subsequently appraised for eligibility independently by two authors (CG and YK). The resulting studies then underwent full-text review, to determine appropriateness of inclusion in the qualitative synthesis phase. The screening and eligibility appraisal process were repeated for the reference lists of the included studies. Disagreements were resolved by initial discussion between reviewers (CG and YK) with pre-planned involvement of a third reviewer (MF) to achieve consensus.

Data extraction and analysis

From the included papers we extracted data on these variables: study setting and size, methodology and participants, the identified and tested HFs, stressors, study interventions, and the outcomes measured, particularly those relating to decision-making.

Assessment of quality of identified papers

Regarding risk of bias, in accordance with NHRMC recommendations. We used the Cochrane risk of bias tool version 2.0 (ROB 2.0) for RCTs.[5] Two independent authors (CG and YK) assessed the risk of bias for the five domains of potential bias. We then compared the results and a consensus was reached.

Results

Study selection

22,368 records in total were identified through database searching. After removal of duplicates 17,620 titles were available for screening. From this, 409 abstracts were reviewed. Eighty-two unique full text studies were identified for review, of which 14 were included. An additional two studies were identified from the reference lists of the included studies and two new studies were identified in the up-to-date search resulting in 16 studies for synthesis (Fig. 1).

Study characteristics

Sixteen studies, comprising 570 participants, were included in the final qualitative synthesis (Table 1). Studies were published between 1995 and 2018. The individual study size ranged from 8 to 115 (Table 1). The studies were conducted in several different countries. Three studies were conducted in the UK, 2 in the United States and Australia. The remaining studies came from Afghanistan, Brazil, Canada, France, Germany, Ireland, South Africa.

Quantitative synthesis via meta-analysis was not possible because of heterogeneity of interventions and outcome measures.

Table 2 – Study type, setting, stressors and mitigators, outcome measures.

Study	Study type	Sim/reality	Stressor	Mitigating/intervention	Outcome measures
Randomised trials					
Hardy et al.[13]	RCT	Sim	Malignant hyperthermia crisis simulation	Checklist guiding correct management	Performance evaluation tool; Technical skill; Non-technical skills (ANTS); Subjective stress (VAS)
Harvey et al.[14]	Randomised cross-over trial	Sim	A critically injured patient at high risk for death; conflict; socio-evaluative stressor; emotional content; noise	A patient with non life-threatening injuries	State-Trait Anxiety Inventory (STAI); Physiologic Stress (heart rate, salivary cortisol); ANTS; Post scenario recall; Performance (global rating)
Krage et al.[16]	Randomised cross-over trial	Sim	Combination of distracting family members (actors) and static noise at 70dB	NA	Non-technical skill (ANTS); Technical skills (novel scoring system developed for this study)
Marshall and Mehra[17]	RCT	Sim	CICO simulation	Cognitive aid	Non-technical skill (ANTS); Technical skill (Time to oxygenation)
Wetzel et al.[21]	RCT	Sim	Complication during simulated operation (Stroke)	Stress Management Training Suite of interventions	Stress assessment (STAI, HRV, Cortisol); Number coping strategies; Surgical performance (observer assessment - included decision making); Qualitative "how beneficial?"
Prospective observational studies					
Anderson et al.[6]	Prospective qualitative study	Sim	Uncertainty around decision making	Specialty/years in practice/ gender	Clinical uncertainty questionnaire; Simulated case performance (calculated by ILIAD computer program)
Arul et al.[7]	Prospective qualitative study	Real	Shocked trauma patients	Trauma WHO checklist communication aid	Standardised Questionnaire (prepared by experts in psychology and communication) of staff members view on communication during resuscitation
Doleman et al.[9]	Prospective observational study	Real	ASA 3 or 4	ASA 1 or 2	Stress physiology (HRV); Subjective stress (STAI); Non-technical performance (ANTS)
Flinn and Armstrong[11]	Prospective observational study	Real	Fatigue from work shift	NA	Cognitive function (Mindstreams medical test); Clinical decision making (Key Features Problems, decision speed)
Folscher et al.[12]	Prospective cross-over study	Sim	Noise and time pressure	NA	OSCE performance and speed; Subjective stress assessment
Kelm et al.[15]	Single-group pretest–posttest convergent mixed-methods study	Sim	Simulated cardiac arrest scenarios	Mindfulness training	Qualitative emotional balance (Positive & negative affect scale); Trait emotional intelligence questionnaire, Stress (skin conductance); Technical performance (time to interventions); Non-technical performance (Team Emergency Assessment Measure (TEAM))
Interview/cross-sectionals					
Castro and de Almondes[8]	Questionnaire	Sim	Night shift	Sleep	Iowa Gambling Task; Hypothetical clinical scenario decision-making; Sleepiness/sleep quality assessment battery

Table 2 (continued)

Study	Study type	Sim/reality	Stressor	Mitigating/intervention	Outcome measures
Flin et al.[10]	Interview - retrospective using novel human factors tool	Real	Unexpected incident e.g. patient deterioration, implied by post-hoc analysis	Teamwork, strong leadership, preparation, & situational awareness were recalled as mitigating factors.	Human Factors Investigation Tool (HFIT) assessment via telephone interview
McClelland et al.[18]	Prospective qualitative study	Real	Hours worked (shift work)	NA	Judgement policy score - based on changes in judgement about standarised clinical scenarios pre- & post-shift; subjective alertness (VAS); subjective stress (VAS); Sleepiness (VAS)
Pietsch et al.[19]	Qualitative questionnaires	Sim	Complex situation management, austere environment	Multi-disciplinary simulation-based training	Self-evaluation questionnaire across numerous non-technical skill domains including decision-making and situational awareness
Schnittker et al.[20]	Qualitative study - Critical decision method interview technique	Real	Critical incident during airway management	NA	Thematic identification of enablers and barriers

NA = Not available; RCT = Randomised Controlled Trial; ASA = American Society of Anesthesiologists Score; CICO = can't intubate, can't oxygenate; ANTS = Anaesthetists' Non-Technical Skill Score; VAS = Visual Analogue Scale.

Results of individual studies

Table 2 details the different study methodologies and exposures. Of the 16 included studies, 5 were RCTs, 6 were prospective observational, and 5 were interviews or cross-sectional. Five of the studies, but none of the RCTs, involved real stressors or scenarios.

Risk of bias within studies

We assessed the risk of bias within the individual studies. Among the 5 RCTs, 3 were deemed to have a high risk of bias (Table 3).

Fig. 2 provides an overview of the identified stressors and mitigators.

Stressors

The stressors assessed in the included studies were markedly heterogeneous. In those studies using simulation, manipulation of the simulation to generate a 'high' and 'low' stress version was used in three of the studies. Harvey et al. increased the stress level of the simulation by choosing an emotive case for the clinical resuscitation (young pregnant female paramedic) and adding a socio-evaluative stressor (the patient's boss, an upset senior paramedic who was critical of the team's performance). They found that the high stress scenario did impair overall clinical performance as assessed by experts reviewing video footage of the scenario, however decision-making per se, as a component of the Anaesthesia Non-Technical Skills (ANTS) assessment, was not deemed to be impaired by the higher stress scenario.[14]

Noise as a stressor was assessed by two studies. Folscher et al. assessed the effect of different levels of ambient noise on emergency medicine doctors undertaking a clinical exam under high or low stress conditions (85 dB and 52 dB respectively).[12] Although the participants did report subject distress due to the noise, their performance was not impaired. Krage et al.[16] used cardiac arrest scenarios with actors as distracting family members, as well as a constant noise stimulus, to increase the stress of the participants during the simulation. They also used the ANTS assessment and found that stress did impair the non-technical skills of the team leader, including a statistically significant impairment of decision-making (Mean difference in ANTS score 3.9, $p < 0.001$), and that this correlated with impaired technical performance (as measure by a scoring system tailored to the simulation scenario developed by the study authors) of the team when these external stressors were present.

Two studies assessed the effect of fatigue due to shift work.[8,11] Castro and de Almondes[8] showed that good sleep quality, related to shift pattern, was associated with more consistent decision-making for hypothetical clinical scenarios in prehospital emergency medicine physicians. Flinn et al.[11] looked at junior doctors' decision-making ability and assessed questions on a clinical scenario, as well as general cognitive skills (as measured by the MindStreams® Global Assessment Battery), and showed that all measures were impaired by long working hours relative to when rested (clinical decision-making scores were on average 15.2% lower ($p < 0.05$) and 10% slower ($p < 0.01$)).

Managing patients who are more unwell increases stress for the clinician and has been shown to impair decision-making. Doleman et al.[9] studied the stress experienced by senior anaesthetists caring for patients with different American Society of Anaesthesiologist

Table 3 – Risk of bias assessment for the five RCTs.

Study	Design	Domain 1: Risk of bias arising from the randomisation process	Domain 2: Risk of bias due to deviations from the intended interventions	Domain 3: Missing outcome data	Domain 4: Risk of bias in measurement of the outcome	Domain 5: Risk of bias in selection of the reported result	Final risk of bias assessment
Harvey et al.[14]	Cross-over	Low	High				High risk
Krage et al.[16]	Cross-over	Low	High				High risk
Wetzel et al.[21]	Parallel	Some	Some	Low	High	High	High risk
Hardy et al.[13]	Parallel	Low	Low	Low	Low	Some	Some concerns
Marshall and Mehra[17]	Parallel	Low	Low	Low	Low	Some	Some concerns

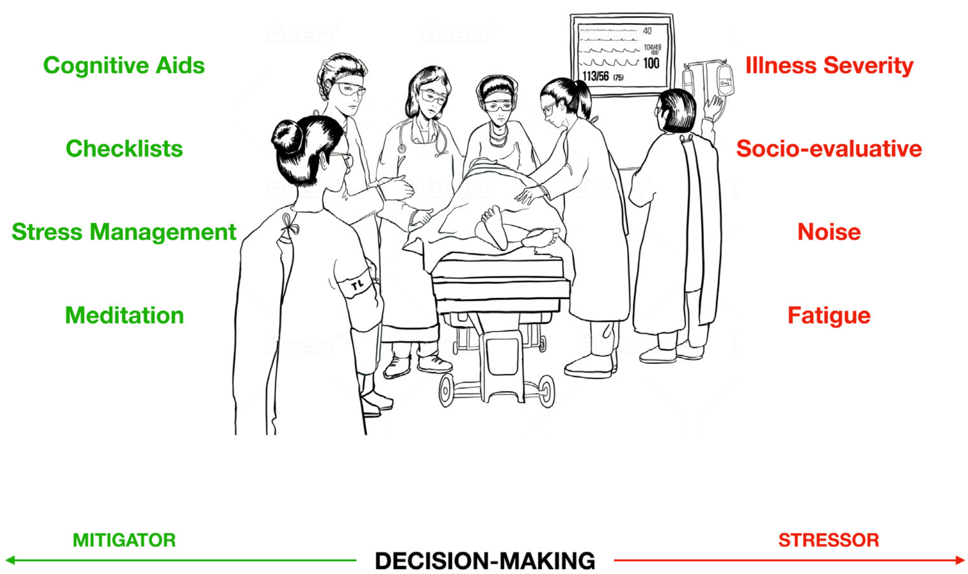

Fig. 2 – Identified stressors and mitigators from the literature.

(ASA) grades, which is a global measure of baseline physical health. More unwell patients caused more stress, which was assessed objectively with heart rate variability (HRV) and subjectively with the State Trait Anxiety Inventory (STAI). The non-technical performance of these clinicians was assessed using ANTS and both the decision-making and situational awareness domains were significantly impaired when anaesthetists cared for the more unwell patients.

Mitigating interventions

Four studies looked at stressful simulations and randomised patients to a potential mitigator of the stress. Two of these studies employed a cognitive aid. In the study by Marshall and Methra,[17] experienced critical care clinicians took part in a 'can't intubate, can't oxygenate' simulation and were randomised to the presence or absence of a cognitive aid tailored to this scenario. This study demonstrated that the use of the cognitive aid, in the form of a simple linear algorithm, improved the non-technical skills, as assessed by the ANTS score, including a significant improvement in the decision-making domain.

Using a simulated malignant hyperthermia scenario, Hardy et al.[13] assessed the effect of a cognitive aid in the form of a checklist for the management of this rare anaesthetic complication. Their study enrolled anaesthesiologists to take part in a simulation of this crisis and looked at their non-technical performance, again assessed by the ANTS score, as well as technical performance relevant to the case. Anaesthesiologists randomised to receive the checklist specific to this crisis showed significant improvements in non-technical skills, including decision-making.

Certain variants of cognitive aids have also been identified as a potential barrier to successful crisis management. In the Critical Decision Method interviews conducted by Schnittker et al.[20], anaesthetists described complex decision aids in the form of flow charts as a distraction from the workflow of challenging airway management rather than a support.

Only one study was identified where clinicians were specifically taught how to manage stress to mitigate the effects on performance. Wetzel et al.[21] assessed the performance of resident trainee surgeons during two simulated challenging operations and were randomised to a 'Stress Management Training' session between the two scenarios. They found that this brief intervention reduced the physiological (as measured by HRV) and subjective measures of stress (as measured by the STAI), experienced by the residents, as well as improvements in their non-technical skills including decision-making.

Mindfulness meditation practice has been assessed in a similar study by Kelm et al.[15] Participants were a group of interprofessional members of a cardiac arrest response team (ICU doctors & nurses, respiratory therapists and pharmacists) who were assessed on their technical and non-technical performance during simulated cardiac arrest scenarios as well as their stress response to the scenario as measured by skin conductance. Four weeks of meditation practice, guided by a headband biofeedback device, was utilised by all participants who were then reassessed with further cardiac arrest scenarios. Post-intervention, participants had improved emotional balance, improved their non-technical performance in the resuscitation scenarios (teamwork and overall team performance).

In the qualitative interview study of challenging airway management cases by Schnittker,[20] clinicians repeatedly reported that effective communication was an important enabler of success. The communication of difficulties with the anaesthetic nurse and other medical staff was identified as being crucial for success, allowing the team to "share the wisdom of people in the room" and to avoid task fixation by providing alternative options for airway management. Conversely this study also identified communication difficulties, particularly due to personality or hierarchy, between anaesthetists and anaesthetic nurses, as a barrier to successful airway management.

In terms of the secondary aim of this study, to identify the most effective strategies for improving decision-making under stress, no study compared mitigating strategies directly. Carefully tailored cognitive-aids and interventions to improve a clinician's response to stress both appear to lead to improvements in performance.

Discussion

This systematic review has identified studies measuring the effects of stress on decision making in resuscitation. Whilst HFs research is a growing field only 16 studies met the inclusion criteria.

The studies identified have shown that exposure to various stressors, including the severity of the patient's illness, noise, time-pressure, socio-evaluative stress, and fatigue can hinder decision-making.

Moreover, decision-making can be improved despite the effects of stress by implementing cognitive aids (e.g. checklists) and also by teaching clinicians to better manage the deleterious effects through stress management or meditation training.

There were additional studies that assessed simulation as a teaching intervention which, whilst not specifically looking at the effect of stress on performance and thus, not included in the results, did demonstrate improvements in clinicians' non-technical skills including teamwork and decision-making.[22]

During the search many studies were identified that addressed similar issues in non-medical settings which, although not pertaining to resuscitation, focused on the participants dealing with work related stress to continue to make important decisions.[23,24] Studies in police officers have looked at the effect of stress on performance, including decision-making, and assessed novel methods for ameliorating the detrimental effects, particularly by teaching participants to control their physiological responses to stress.[23,24] Arguably, the physiological response to stress experienced by clinicians in resuscitation may be similar to that experienced in other settings and these techniques may be an interesting area of future study in critical care clinicians.

Many studies used HRV as an objective measure of stress[9,21,23,24] but none did this in real-time and this may be a future avenue of research in this field. Using artificial intelligence to monitor the clinician's HRV, and identify when they are stressed, may allow tailored mitigating strategies to be implemented improving decision-making performance.

Table 4 – Haddon Matrix summary of human factors in resuscitation.

	Pre-resuscitation	Resuscitation	Post-resuscitation
Patient and pathology		• Illness severity[9,14,15,17] • Patient deterioration[21]	
Individual clinician and team performance	• Mindfulness training[15] • Mental rehearsal[21] • Staffing levels[10] • Shift work[8,11,18] • Interprofessional simulation-based team training[19]	• Stress from uncertainty[6] • Teamwork[10,15,20] • Stress management[15,21] • Fatigue[8,10,11] • Situational awareness[10] • Time pressure[10,20] • Distraction[16] • Socio-evaluative Stressor[14] • Conflict[14] • Clinician Experience[20]	• Emotional balance[15] • Debrief[7]
Environment and system factors	• Equipment location & preparation[20]	• Noise[12,14,16] • Cognitive Aid[13,17] • Trauma WHO Checklist (structured communication aid)[7]	• Debrief prompted by checklist[7]

Limitations

The databases chosen for the search are all for medical research and although interesting non-medical studies were identified during the process a deliberate decision was made not to include these studies as they are not specific to decision-making in the care of an unwell patient which was the primary focus of this review. The studies identified were heterogeneous which meant that a meta-analysis of the data could not be undertaken and also that the conclusions of the study are based on a range of stressors and mitigating strategies. For example, stressors such as noise and fatigue may reasonably be expected to incur different performance effects than due to conflict or socio-evaluative stress and require different mitigation strategies. Future studies may want to assess whether stressors can be categorised and how these influence decision-making performance in different ways. Currently, what is lacking is a taxonomy that links these factors to resuscitation performance and patient outcomes. We designed a framework, represented as a Haddon Matrix,[25,26] which can be used to categorise the variables identified from the literature and may be useful for future studies. Table 4 demonstrates an example of the framework used to categorise the findings from the included studies.

Conclusion

Decisions during stressful situations in medicine are made frequently and based on limited information. Human factors that contribute to these decisions include noise, conflict, time-pressure, socio-evaluative stress, and fatigue. Understanding these factors and the potential to mitigate their effects may have implications for clinician education and stress management training, as well as the development of decision support tools.

Conflicts of interest

None

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None.

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