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Review Article

Prevalence and commonality of non-technical skills and human factors in airway management guidelines: a narrative review of the last 5 years

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Summary

The primary aim of this review was to identify, analyse and codify the prominence and nature of human factors and ergonomics within difficult airway management algorithms. A directed search across OVID Medline and PubMed databases was performed. All articles were screened for relevance to the research aims and according to predetermined exclusion criteria. We identified 26 published airway management algorithms. A coding framework was iteratively developed identifying human factors and ergonomic specific words and phrases based on the Systems Engineering Initiative for Patient Safety model. This framework was applied to the papers to delineate qualitative and quantitative results. Our results show that human factors are well represented within recent airway management guidelines. Human factors associated with work systems and processes featured more prominently than user and patient outcome measurement and adaption. Human factors are an evolving area in airway management and our results highlight that further considerations are necessary in further guideline development.

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Introduction

Clinical guidelines are tools for improving airway management [1–4]. Theur purpose, along with cognitive aids, is to assist in streamlining clinical decision-making and to minimise human error, ultimately improving patient safety [5]. Disasters in airway management often involve cognitive overload leading to poor decision-making and/or analysis [6]. Human factors concepts such as perception, decision-making and interpersonal communication are subject areas clinicians intuitively understand as important, yet it has taken time for these to be formalised. The first airway guideline was published in 1993

but it took a further 22 y for an airway guideline to include decision-making prompts in an algorithm in the form of the Difficult Airway Society's `*Stop and think*´ [7, 8]. Since then, human factors in various forms have been included in other airway guidelines but the specific types of human factors included in recent guidelines have not yet been studied.

The concept of human factors comprises much more than individual cognition errors (e.g. perceptions and decision-making) or interpersonal communication failures. Human factors permeate everything that affects how work is done, from the culture and regulations affecting an organisation to how equipment and tasks are designed within the complex systems of healthcare delivery. The concept of human factors may be defined as '*environmental, organisational and job factors together with human and individual characteristics, which influence behaviour at work in a way which can affect health and safety*´ [9]. Organisational focus on human factor frameworks is thought to reduce patient harm through numerous checks and balances [10, 11]. Originally evaluated within the aviation industry, the importance of human factors has gained increased attention in healthcare (particularly in acute care) as a way to minimise omissions or errors during time-critical situations [12, 13].

The Systems Engineering Initiative for Patient Safety (SEIPS) model was first published in 2006 by Carayon et al. and was based on data collected over 20 y [14]. The model describes the interaction between work systems, processes and outcomes, as well as people, tools and the environment (Fig. 1). It also attempts to analyse human factors in healthcare system performance by outlining overarching components that `*can contribute to acceptable or unacceptable process*´ and by identifying the specific human factor components in a `*descriptive, not prescriptive*´ manner [14].

We used the SEIPS model framework to quantify the types of human factors included in airway guidelines that have been published within the last 5 y.

Methods

The search strategy is available in online Supporting Information (Appendix S1).

Since there is no validated or accepted taxonomy for human factors, a coding framework was iteratively developed by three authors (SL, SM and MT). The mention of human factors and ergonomics was identified using specific words and phrases based on the SEIPS model. This coding framework was divided into three major domains: work system; processes; and outcomes/adaptation (Table 1). Specific human factors were separated into their most appropriate domain. The work system domain included equipment; tasks; team members; organisational; and internal/external environments. The processes domain included planning; recaps/situational reports; cognitive aids; communication; alarm use; and role allocation. The outcomes/adaptation domain included patient outcomes; user outcomes; and organisational issues.

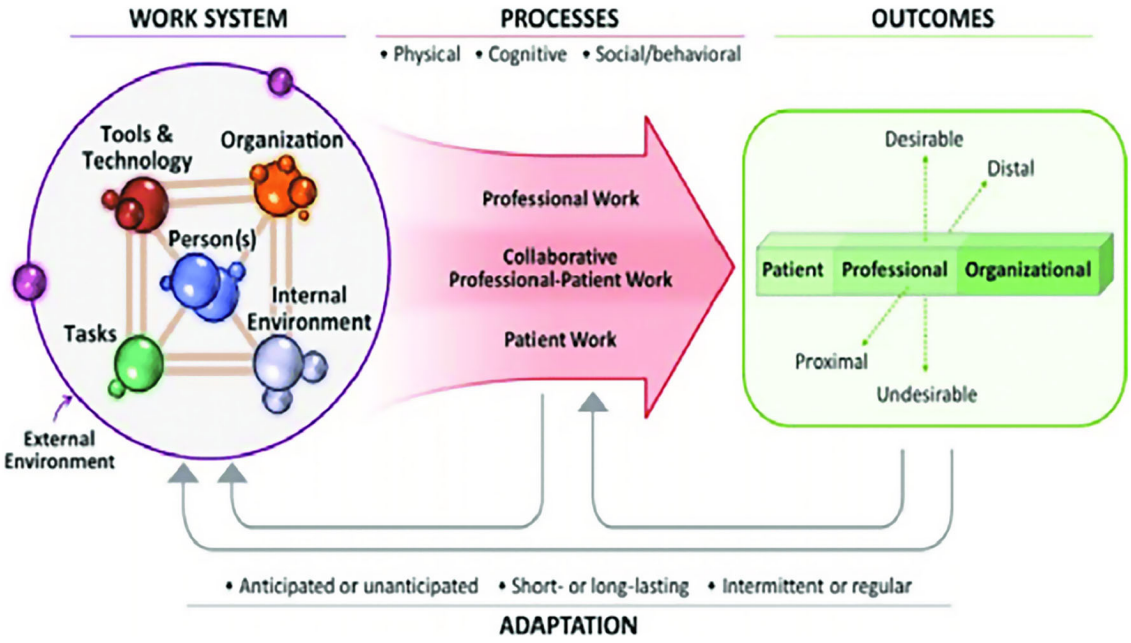

Figure 1 SEIPS 2.0 model reproduced from Holden et al. [15].

Table 1 Coding framework based on the Systems Engineering Initiative for Patient Safety (SEIPS) model.

Work System		
Element	**Definition**	**Terms**
Equipment	Defines what equipment to use Ensures equipment is available and prepared (work surface/kit dump mat) Minimum monitoring equipment (capnography/oximetry) Suggested medications	equipment; equipment select/selected/selecting/selection; equipment preparation; monitoring; work surface; kit dump; knoll; equipment check/checked/checking/checks; syringe size; syringe organisation/organisation; syringe ordering; syringe preparation; medication organisation/organisation; medication ordering; medication preparation; drug organisation/organisation; drug ordering; drug preparation; red-barrelled syringe; red syringe; airway cart; airway trolley; difficult airway cart; difficult airway trolley; equipment availability; equipment storage
Tasks	Defines how tasks are done (CICO and otherwise), for example, where to stand, how to perform (scalpel/bougie cricothyrotomy technique for example)	ergonomics; physical ergonomics; physical space; design; lighting; noise; position/positioned/positioning; layout; location; where; scalpel type; scalpel size; bougie type; bougie size; coudé tip; finger; incision; technique
Team members	Defines minimum number and type of team members Defines skill set of team member(s)	skills; skill-mix; skill-set; training; education; team size; team composition; team member; skills matrix
Organisational	Suggests rostering/organisational issues or team such as airway emergency teams Defines hospital/health service-wide changes	roster; teams; response team; difficult airway response team; DART; emergency team; facilities; purpose-built; specialist; specialised/specialised; MET team; MERT team; organisation/organisation; health service; health district; code blue/red/black; service change/changed/changes; service alteration; service-wide change; service-wide alteration; schedule/scheduling/scheduled; emergency response
Internal environment	Describes modification of internal environment – minimise noise, distraction Outlines engineering principles such as negative pressure/airflow characteristics	internal environment; noise minimisation/minimization; distract/distraction; interrupt; airflow; negative pressure; below 10,000/10,000; sterile cockpit; sterile communication/s; alarms; temperature; light; lighting
External environment	Suggests broader legal/regulatory changes or systems larger than single health service	law; legal; regulatory; multi-site; licence; licence; certify; board; regulation; legislative change; medical board
Processes		
Planning	Suggests pre-case planning/huddle Checklist provided or suggested Written (explicit) protocols and plans made (e.g. via a whiteboard) How plans and protocols are agreed and communicated	plan/planned/planning/plans; protocol/s; check-list/checklist; whiteboard; strategy; huddle; pre-brief; algorithm; preparation; time-out; shared mental model; common understanding; airway assess/assessed/assessing/assessment; chart review
Recaps/situation reports	Describes pauses for team situation awareness/team suggestions Provides a structure for these recaps Provides framework for team decision-making	awareness; recap; decision-making; situational awareness; stop and think; pause; sitrep/sit-rep; SNAPPI; callout/call-out

(continued)

Table 1 (*continued*)

Processes		
Cognitive aids	Provides or suggests a cognitive aid Defines who reads a cognitive aid Defines how the cognitive aid is used (e.g. challenge-response) Advises physical/electronic properties of the cognitive aid	cognitive aid; challenge-response; call-response; mnemonic; acronym; poster; algorithm; reader; verify; verification; display; displayed; screen-based; electronic; aide-memoire; memory aids; prompts
Communication	Mentions closed-loop communication Advises or promotes a Graded Assertiveness method to prevent fixation Defines what information requires explicit versus implicit coordination Promotes `sterile´ periods of communication Uses specific `critical language´	communication; closed-loop/closed loop; sterile communication/s; implicit co-ordination/coordination; explicit co-ordination/coordination; explicit communication; speak up; escalation; assertiveness; critical language; non-verbal communication; read out/readout/read-out; readback/read back/read-back; fixation
Alarm use	Suggests methods to deal with alarms Suggests methods to maintain awareness of time elapsed	alarm/alarms; situational awareness; fixation; alarm fatigue; time dilation; time contraction; time awareness; elapsed; help; call for help; emergency button; red button
Role allocation	Defines minimum roles Defines who allocates roles Defines how the leadership role is assigned and/or reassigned Defines followership roles	role allocation; role assignment; role delegation; leader; follower; task management; task assignment; team dynamics; interpersonal/ inter-personal
Outcomes/adaptation		
Patient outcomes	Assesses morbidity and mortality of airway management episodes Advises a system for incident reporting and learning	morbidity; mortality; incident report/reporting; review; learning; case conference; quality improvement; quality assurance
User outcomes	System exists for collecting and incorporating feedback to future versions Assessing processes of airway management episodes in simulation	feedback; safety; simulation; resilience; resilience engineering; feed forward; performance assessment
Organisational issues	Underpinned by a reputable body which is sustainable	sustain; review; review process; re-engineer; re-design; society; committee; consultation; medical college

NVivo analysis software (Version 1.5.1; QSR International Pty Ltd., Chadstone, Victoria, Australia) was used to analyse the text. The coding framework (Table 1) along with the 26 airway guidelines was inputted for analysis. Each guideline was analysed for the presence and number of coded human factors terms. To ensure optimal capture of human factors data, each guideline was also evaluated by one of two authors (DE or DB) to extract any other human factors that may have not been extracted with the coding software.

The resulting coding matrices were exported and further analysed on Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) with tables and illustrative charts formulated. A comparative illustration of the distribution of the three major human factors components is shown along with other findings in online Supporting Information (Appendix S2).

Quantitative categoric analysis of the human factor types in the three domains was recorded, with prevalence of each subdomain also analysed. The results were tabulated to delineate if all, some or none of the subdomains were present for each paper.

Results

In the last five years (May 2016–May 2021), 26 airway guidelines were identified (Table 2). Of these, more than half were published after January 2020 (n = 18) and 13 were COVID specific.

Overall, we found that items relating to human factors were well represented in the 26 included airway guidelines. Terms relating to work system were the most frequently mentioned; all six elements of the work system domain were present in all included guidelines. The other two major domains as defined by the SEIPS model, processes and

Table 2 Included guidelines.

Year Published	Professional airway group and reference	Country	COVID-19 specific
2021	Canadian Airway Focus Group [16]	Canada	N
2021	Society for Airway Management [17]	USA	N
2021	French Society of Anaesthesia and Intensive Care Medicine [18]	France	Y
2021	Society of Airway Management [19]	USA	Y
2020	Difficult Airway Society [1]	UK	N
2020	Canadian Anesthesiologists' Society [20]	Canada	N
2020	Catalan Society of Anesthesiology [21]	Spain	N
2020	Anaesthesia Patient Safety Foundation [22]	US	Y
2020	Joint Task Force of the Chinese Society of Anesthesiology and the Chinese Association of Anesthesiologists [23]	China	Y
2020	Safe Airway Society [24]	Australia	Y
2020	Difficult Airway Society (DAS), Association of Anaesthetists, Intensive Care Society, Faculty of Intensive Care Medicine and the Royal College of Anaesthetists [25]	UK	Y
2020	Società Italiana di Anestesia Analgesia Rianimazione e Terapia Intensiva (SIAARTI) and the European Airway Management Society [26]	Italy	Y
2020	Indian Society of Anaesthesiologists [27]	India	Y
2020	Chinese Society of Anesthesiology [28]	China	Y
2020	All India Difficult Airway Association [29]	India	Y
2020	Korean Society of Anesthesiologists [30]	Korea	Y
2020	Taiwan Association of Anesthesiologists [31]	Taiwan	Y
2020	N/A [32]	International	Y
2019	French Society of Anaesthesia and Intensive Care Medicine and French-speaking Intensive Care Society [33]	France	N
2018	Difficult Airway Society [3]	UK	N
2018	Société Française d'Anesthésie et de réanimation [34]	France	N
2017	French Society of Anaesthesia and Intensive Care Medicine [35]	France	N
2017	Chinese Collaboration Group for Emergency Airway Management [36]	China	N
2017	Association of Anaesthetists [37]	UK	N
2016	All India Difficult Airway Association [38]	India	N
2016	All India Difficult Airway Association [4]	India	N

outcomes/adaptations, were well represented. Within the processes domain, planning and role allocation were the prominent elements identified. Within outcomes/adaptations, organisational issues were shown to be the predominant element with user outcomes the least mentioned element. Table 3 illustrates the prevalence of each major domain among the papers.

Discussion

In this review, we aimed to explore how human factors appear within airway management guidelines. We describe the domains and elements and quantify the nature of the recommendations included in these 26 published airway guidelines in relation to an accepted healthcare system safety framework, SEIPS.

The concept of an `airway time-out´ has gained more traction in the recent literature and is commonly included in guidelines. By contrast, there are newly developed process and communication interventions which are generally not yet included. These emergent ideas include `sterile communication´, a concept where all non-essential communication/activity is banned at critical phases of airway management, stating of glottic view by the airway operator and confirmation of exhaled carbon dioxide to the team. The authors believe that if these new interventions prove effective, they should be included in future guidelines as a means to improve communication at critical event intervals and reduce cognitive workload.

Collectively, human factors recommendations were well represented in the 26 airway guidelines. However,

Table 3 Prevalence of human factors of each included paper as per the three Systems Engineering Initiative for Patient Safety (SEIPS) domains.

	Work systems	Processes	Outcomes/adaptation
Law et al. [16]	X	X	X
Kornas et al. [17]	X	Z	Z
Velly et al. [18]	X	Z	X
Foley et al. [19]	X	Z	Z
Ahmad et al. [1]	X	X	Z
Dobson et al. [20]	X	X	X
Lopez et al. [21]	X	X	Z
Zucco et al. [22]	X	Z	Z
Chen et al. [23]	X	Z	O
Brewster et al. [24]	X	X	X
Cook et al. [25]	X	Z	Z
Sorbello et al. [26]	X	Z	Z
Malhotra et al. [27]	X	Z	O
Zuo et al. [28]	X	Z	O
Patwa et al. [29]	X	Z	Z
Kim et al. [30]	X	Z	Z
Ting et al. [31]	X	Z	Z
Yao et al. [32]	X	Z	Z
Quintard et al. [33]	X	Z	X
Higgs et al. [3]	X	X	X
Langeron et al. [34]	X	Z	Z
Quintard et al. [35]	X	Z	Z
Sun et al. [36]	X	Z	O
Lockey et al. [37]	X	Z	X
Myatra et al. [38]	X	Z	X
Myatra et al. [4]	X	Z	X

X, all subdomains present; Z = some of the subdomains present; O, no subdomains present.

some subcategories were less well represented. For example, within the cognitive aids element, analysis distinguishing between algorithms and cognitive aids revealed less than half of the guidelines illustrated or demonstrated a cognitive aid. Of the 22 guidelines which included coding terms associated with cognitive aids, 15 simply referred to their importance in the management of the airway or referenced articles discussing cognitive aids but failed to mention or detail a specific cognitive aid in the guideline.

Research involving simulation supports the use of cognitive aids in anaesthesia, as well as in other fields of medicine [39–42]. Despite the increased focus on human factors in anaesthesia, and the known evidence supporting the use of cognitive aids to reduce slips, lapses and mistakes, cognitive aids were not included in four guidelines, and mentioned but not presented in an additional 15, totalling 19 of 26 (73%) [43]. Cognitive aids can and should be adapted to fit the local context with variations in protocols, availability of equipment and training across hospitals [41]. The process of adaptation of cognitive aids has been shown to be associated with improved implementation, with lack of local adaptation and unsatisfactory design being associated with poor implementation and adoption of cognitive aids across hospital networks [44].

A key feature of the SEIPS model of healthcare system safety is that analysis of patient and user outcomes data allows organisations and individuals to redesign the work system via a feedback loop. Our study has demonstrated that patient and user outcomes were the least represented human factors recommendations overall, making up less than one-fifth of all coding terms identified. More strikingly, we found that the author's perceived experience of increased focus of user outcomes as a result of the COVID-19 pandemic appears not to be reflected in the

Table 4 Key recommendation for guideline development.

- Future research and guideline development should consider a systems-based approach to airway management
- Guideline development should maintain human-centred design
- Cognitive aids, simulation programs and outcomes should be included
- Systems for review processes which allow for local adaptation of guidelines integrating both patient and user should be implemented
- Following the implementation of an airway guideline, feedback from both user and patient outcomes should be allowed for further development and updates

corresponding COVID-19-specific airway guidelines. This was evidenced by user and patient outcomes elements making up a smaller proportion of mentions in non-COVID-19-specific guidelines compared with COVID-19-specific guidelines. It may be appropriate that the scale is still tipped towards content heavier work system recommendations but the comparative lack of outcome measurement and adaption is a key finding from our study which should be addressed. The authors believe that future guideline development (or updates) should allow for feedback from both user and patient outcomes following the implementation of an airway guideline. By facilitating this feedback, appropriate adaptation could potentially form part of a much-needed improvement in the evidence basis from which airway guidelines are designed. The key recommendations of this paper are found in Table 4.

This is a novel narrative review detailing the prevalence of human factors terms and recommendations within airway management guidelines. It is also the first review that stratifies specific human factor themes as per the SEIPS model and details within current airway management guidelines which human factor themes are most commonly included and, perhaps more importantly, which remain absent.

The primary limitation of this paper is the narrow scope of airway guidelines limited to the last five years. This recent snapshot allowed the authors to examine and analyse the tone of human factors in airway guidelines related to current practice; however, it limited the ability to examine trends over a longer period of time.

In conclusion, human factors are generally well represented within current airway management guidelines. Many clinicians have an intuitive understanding of the importance of communication, insight into their cognitive biases and the need for efficient and effective workspaces. How we address human factors systematically during guideline development remains an area in development. By assessing which human factors have been emphasised in airway management guidelines, this may perhaps guide us to which human factors are well represented, and which are yet to be fully addressed.

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Supporting Information

Additional supporting information may be found online via the journal website.

Appendix S1. Search strategy.

Appendix S2. Results of coded human factor term search.