32)	ANOPS	131.37	Provide assistance as requested
33)	Kennedy tower	119.1	(Approaching runway 04 left) 'Clipper 594 "Heavy cross runway 22 right left on the inner contact Kennedy ground control on frequency 121.9
34)	Kennedy ground	121.9	'Clipper 594 Heavy taxi via the inner to your gate"
35)	Atlanta flight support	131.25	Receive block arrival message

ALTERNATE WEATHER REPORTS (IF REQUESTED)

Newark	300 obscured Visibility 1/2 mile, snow, fog Temperature 30 dew point 29 wind 350 at 5 knots altimeter 29.72
Philadelphia	400 obscured Visibility 1/2 mile, snow, fog Temperature 31 dew point 29 wind 010 at 4 knots, altimeter 29.70
Boston	Measured 800 overcast Visibility 3 miles, snow Temperature 15 dew point 11, wind 010 at 7 knots altimeter 29.56
Bradley	Measured 400 overcast Visibility 3/4 mile snow Temperature 20, dew point 17 wind 020 at 5 knots altimeter 29.68
Baltimore	Estimated 400 overcast Visibility 1 mile, snow fog Temperature 30 dew point 27, wind 020 at 7 knots altimeter 29.59
Andrews AFB	Measured 400 overcast Visibility 1 mile snow Temperature 31 dew point 27, wind 020 at 5 knots Altimeter 29.60

PAN AM LOFT SCENARIO (9-26-88)

CLIPPER 594 "HEAVY" IAD-JFK (A-310)

Problems 1, 8, 9, 10 (See problem menu)

1) SIM setup		Dulles runway 01R (#), Gate #3, taxi weight 233 900 lb, fuel 22 500 lb take-off CG 29 2%, ceiling 1 000 ft, cloud tops 3 000 ft, visibility 10 000 RVR, OAT 30F (-2C) altimeter 29 59 Hg (1 002 mb) wind 020/8, QXI/OCI #1 Green-to-blue hydraulic PTU INOP QXI/OCI #2 Left inner fuel tank pump 1 INOP Insert Problem 1
2) Dep ATIS	134 85	"This is Washington Dulles departure information ZULU Ceiling measured 900 overcast, visibility 2 miles in light snow temperature 30, dew point 28, wind 020 at 8, altimeter 29 59 Departures expect runway 01 right Inform clearance or ground control on initial contact that you have received information ZULU '
3) Clearance delivery	127 35	"Clipper 594 "Heavy", cleared to JFK capital two departure as filed, fly runway heading for vectors on course maintain 4 000 ft, expect 17 000 ft ten minutes after take-off Departure control frequency is 125 05, squawk 0523, contact Dulles ramp control on 129 55 prior to taxi '
4) Routing		Radar vectors direct Baltimore V-44, V-229 MORTN, V-44 CAMRN, direct JFK
5) Ground support		Clearance to pressurize hydraulics, remove external electric (as appropriate) Clearance to start engines when requested Remove external connections when directed "Standby for hand signals on your left."
6) Ramp control	129 55	Receive pushback request 'Clipper 594 'Heavy" cleared to push back, face east " Receive taxi request "Clipper 594 "Heavy" taxi eastbound to taxiway Echo-1, turn right and taxi south, then contact Dulles ground control frequency 121 9 "
7) Ground control	121 9	"Clipper 594 'Heavy", continue taxi runway 01 right "
8) Atlanta flight support	130 9	Receive blocks departure message
9) PANOPS	129 7	Receive off blocks time and gallons of fuel added
10) Load control	129 7	"Clipper 594 "Heavy", load control Your zero fuel weight is 210 6 with a CG of 27 2 your take-off weight is 233 1 with a CG of 29 2 Passenger load is 12 first class, 21 clipper, and 103 coach Stabilizer setting is 0 1 up '
11) Ground control	121 9	(Approaching runway 01R) "Clipper 594 "Heavy", contact Dulles tower frequency 120 1 "
12) Tower	120 1	"Clipper 594 "Heavy", wind 020/8 maintain runway heading, cleared for take-off "
13) Tower	120 1	'Clipper 594 "Heavy" turn right heading 080, vectors on course contact departure control frequency 125 05 "
14) Departure control	125 05	'Clipper 594 'Heavy" radar contact continue heading 080 vectors to Baltimore, climb to and maintain 6 000 ft receiving Baltimore cleared direct '

15) Departure control	125 05	(Approximately 20 miles west of Baltimore VOR) Clipper 594 Heavy contact Washington Centre on 133 9
16) Washington Centre	133 9	'Clipper 594 Heavy radar contact maintain 17 000 ft and cleared via flight plan route
17) Atlanta flight support	131 25	Receive airborne message
18) Problem		(Approximately overhead Baltimore) Insert Problem 8 or 9 or 10
19) Washington Centre	133 9	(When requested) 'Clipper 594 "Heavy for vectors back to Dulles turn right heading 250 descend to 10 000 ft, Dulles altimeter 29 59 Hg (1 002 mb) ' Provide information as requested Provide return (or diversion) vectors
20) ARVL ATIS	134 85	'This is Washington Dulles arrival information CHARLIE Ceiling measured 900 overcast, visibility 2 miles in light snow, temperature 30, dewpoint 28 wind 020 at 8 altimeter 29 59 Arrivals expect ILS approach runway 01 right departures runway 01 right Notice to airmen ILS runway 01 right glideslope out of service Inform Dulles approach control that you have received arrival information CHARLIE "
21) PANOPS	129 7	Receive in-range message Provide assistance as requested
22) SIM setup		IAD runway 01 right (#), ceiling 800 ft, cloud tops 3 000 ft, visibility 10 000 RVR OAT 30F (-2C) altimeter 29 59 Hg (1 002 mb) wind 020/8 Glideslope 01 right inoperative
23) Washington Centre	133 9	(Approximately 20 miles east of Dulles) "Clipper 594 'Heavy ' contact Dulles approach control on frequency 120 45
24) Approach control	120 45	Clipper 594 'Heavy' , radar contact, maintain heading 250, descend to 3 000 ft, vectors for the ILS final approach course runway 01 right Dulles altimeter is 29 59 Hg (1 002 mb) " Provide assistance as requested Any runway available upon request (on final vector) "Clipper 594 'Heavy" contact Dulles tower, frequency 120 1 '
25) Tower	120 1	"Clipper 594 "Heavy", wind 020/8, cleared to land runway 01 right " (During rollout) "Clipper 594 "Heavy", contact Dulles ground control frequency 121 9 "
26) Dulles ground	121 9	"Clipper 594 "Heavy ', taxi to your gate ' (or to remote parking) Provide assistance as requested
27) PANOPS	129 7	Provide assistance as requested

ALTERNATE WEATHER REPORTS (IF REQUESTED)

Newark	300 obscured Visibility 1/2 mile snow fog Temperature 30, dew point 29, wind 350 at 5 knots, altimeter 29 72
Philadelphia	400 obscured Visibility 1/2 mile, snow, fog Temperature 31, dew point 29, wind 010 at 4 knots altimeter 29 70
Boston	Measured 800 overcast Visibility 3 miles snow Temperature 15, dew point 11 wind 010 at 7 knots altimeter 29 58

Bradley	Measured 400 overcast Visibility 3/4 mile snow Temperature 20, dew point 17, wind 020 at 5 knots altimeter 29 68
Baltimore	Estimated 400 overcast. Visibility 1 mile snow, fog Temperature 30, dew point 27 wind 020 at 7 knots, altimeter 29 59
Andrews AFB	Measured 400 overcast Visibility 1 mile, snow Temperature 31 dew point 27, wind 020 at 5 knots Altimeter 29 60

＜資料8＞

より安全な医療を求めて－医療安全に関するエビデンス・レポート－

第44章　クルー資源管理とその医学への応用

（原文）

Making Health Care Safer A Critical Analysis of Patient Safety Practices

Chapter 44 Crew Resource Management and its Application in Medicine

医療安全ハンドブック③

より安全な医療を求めて

――医療安全に関するエビデンス・レポート――

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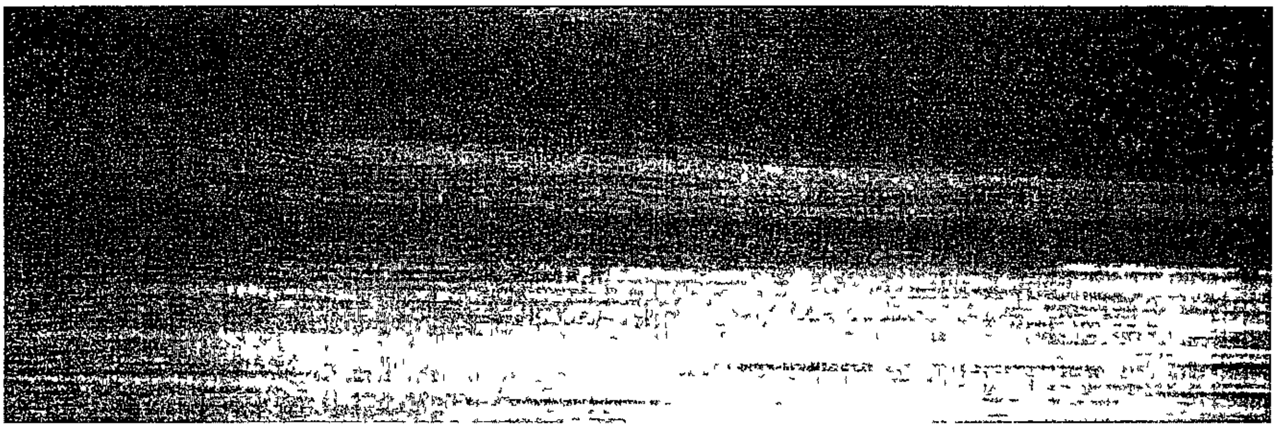

Making Health Care Safer: A Critical Analysis of Patient Safety Practices

Prepared for, Agency for Healthcare Research and Quality
U S Department of Health and Human Services
Prepared by, University of California at San Francisco (UCSF)-
Stanford University Evidence-based Practice Center

メヂカルフレンド社

Evidence Report/Technology Assessment

Number 43

Making Health Care Safer: A Critical Analysis of Patient Safety Practices

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Chapter 44 Crew Resource Management and its Applications in Medicine

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Background

Patient care, like other technically complex and high risk fields, is an interdependent process carried out by teams of individuals with advanced technical training who have varying roles and decision-making responsibilities While technical training assures proficiency at specific tasks, it does not address the potential for errors created by communicating and decision making in dynamic environments Experts in aviation have developed safety training focused on effective team management, known as Crew Resource Management (CRM) Improvements in the safety record of commercial aviation may be due, in part, to this training[1] Over the past 10 years, lessons from aviation's approach to team training have been applied to patient safety, notably in intensive care unit (ICU) and anesthesia training[2,3] This chapter reviews the literature on Crew Resource Management, also known as Cockpit Resource Management, and describes adaptations of this training framework to medicine

Practice Description

Crew Resource Management in Aviation

Crew Resource Management has been widely used to improve the operation of flight crews The concept originated in 1979, in response to a NASA workshop that examined the role that human error plays in air crashes[4] CRM emphasizes the role of human factors in high-stress, high-risk environments John K Lauber, a psychologist member of the National Transportation Safety Board, defined CRM as "using all available sources—information, equipment, and people—to achieve safe and efficient flight operations"[5,6] CRM encompasses team training, as well as simulation (also referred to as *Line-Oriented Flight Training*, or LOFT), interactive group debriefings, and measurement and improvement of aircrew performance

There is no universal CRM training program The Federal Aviation Administration (FAA) allows air carriers to customize their CRM programs to best suit the needs of individual organizations Therefore, training programs vary somewhat from carrier to carrier, making it difficult to describe operational components Furthermore, these programs continue to evolve as aviation technology changes and more is learned about group dynamics

One CRM model focuses on the elements of human effectiveness[7] The 3 primary components of effective crew management are safety, efficiency, and morale Specific factors related to aircrew performance are categorized, and serve as the basis for training and research These factors include materials, organization, individual, and group process variables associated with performance[8] Examples of outcomes that result from these input variables are safety, efficiency, and customer satisfaction

Subsequently, Helmreich and colleagues proposed a modified conceptual framework for CRM, termed the "Error Troika,"[9] to display a hierarchy of 3 error countermeasures At the first level, CRM includes training on how to avoid errors At the second level, potential errors are "trapped" before they are committed At the third level, mitigation of error consequences occurs

From a practical standpoint, CRM programs typically include educating crews about the limitations of human performance [10] Trainees develop an understanding of cognitive errors, and how stressors (such as fatigue, emergencies, and work overload) contribute to the occurrence of errors Multi-day CRM training programs typically require participants to assess personal and peer behavior Operational concepts stressed include inquiry, seeking relevant operational information, advocacy, communicating proposed actions, conflict resolution and decision making

Prevalence and Severity of the Target Safety Problem

The field of aviation has a substantial history of collecting and analyzing safety-related data Historically, human error has caused or contributed to over 50% of aviation accidents In an analysis of 35,000 reports of incidents over 7 5 years, almost 50% resulted from a flight crew error, and an additional 35% were attributed to air traffic controller error [11] Root cause analyses (Chapter 5) by safety experts have found that errors frequently occur because flight crews fail to effectively manage the resources available to them (eg, fail to verify information when uncertain about it, fail to plan for contingencies) [11] Naval aviation reports provide similar results, with one study reporting 59% of "Class A mishaps" (serious consequences including fatality, destroyed aircraft, and major injury) attributed to some degree to aircrew factors [12] These and similar analyses have catalyzed tailored prevention strategies including CRM for commercial aviation,[1] and "aircrew coordination training" (ACT) for Naval aviators [12]

Study Design and Outcomes

Measures

Although the most obvious and meaningful measure of CRM effectiveness would appear to be airline accident or "near miss" rates, these objective measures have not been used in commercial aviation studies Helmreich suggests that it is not possible to use these measures, because accident rates are very low and "near misses" are voluntarily reported [10] Furthermore, the content and structure of CRM training programs are variable [10]

In response, researchers have developed tools that assess the effectiveness of CRM in other ways These tools include attitudinal surveys and peer performance rating questionnaires, including the NASA/University of Texas Line/LOS Checklist (LINE/LOS Checklist),[13] the Cockpit Management Attitudes Questionnaire (CMAQ), and the Flight Management Attitudes Questionnaire (FMAQ) The LINE/LOS Checklist is used to rate crew performance on critical behaviors during specific segments of flight (eg, not rushing through briefing period, exhibiting high levels of vigilance in both high and low workload conditions, etc) Ratings on each behavioral element (ie, model for teamwork) range across 4 levels from poor to outstanding

In contrast, CMAQ is used to evaluate the attitudes of crewmembers within and between organizations, pre- and/or post-CRM training Results are intended to serve as a proxy for measuring crew process and performance [14] The instrument has been validated by comparing self-reported attitudes with performance ratings made by experienced Check Airmen, experts trained in peer evaluation [15] The FMAQ is a revised version of the CMAQ that was developed by Helmreich and colleagues in response to attitudinal differences observed in flight crews from different countries [16]

Observation of crew performance in simulated flights has also been used

Representative Studies

Several studies have utilized proxy tools to test the effectiveness of CRM [8,12,17] One study by Helmreich and colleagues consisted of an assessment of the attitudes before versus after CRM training (pre-test versus post-test) [17] Crew behaviors were noted by a trained observer using the NASA/University of Texas Line/LOS Checklist [18] More than 2000 line flights and LOFT sessions were included in the analysis Overall performance of crews was classified as "below average," "average," or "above average" by Check Airmen and LOFT instructors

As a result of the CRM training, the percentage of crews rated as "above average" increased while the percent rated "below average" decreased Performance ratings differed between fleets and airlines Superior pilots also shared many common attitudes, (for example, they were aware of their personal limitations and diminished decision-making capacity during emergencies) In addition, they encouraged crewmembers to question their decisions and actions, were sensitive to the personal problems of other crewmembers, and recognized the need to verbalize plans and to train other crewmembers

A second study by Barker and colleagues compared the effectiveness of 17 CRM-trained flight crews on military mission simulators, divided according to whether they were "fixed" or "formed" crews [8] Nine of the crews were defined as "fixed" since they had flown together for six months or longer, the remaining 8 were "formed," as they had flown together for less than 6 months Each crew was asked to participate in a simulated mission The first leg of the mission was programmed to be problem-free, but the second leg required crews to address a safety issue As with the earlier study, crew behaviors were observed using the NASA/University of Texas Line/LOS Checklist Surprisingly, the formed crews committed fewer minor errors, but the number of major errors did not differ significantly between the groups [8] The authors concluded that formed crews may experience less ineffective coordination than fixed crews, as the latter might be more complacent from the routine of working together, but that further research was needed

A third study evaluated rates of naval aviation mishaps, and the role of CRM failures [12] While the study primarily compared crew performance in 2 types of equipment, the aircrew performance deficits were also compared with those seen during an earlier time period, prior to implementation of aircrew coordinating training (ACT) programs (the specific form of CRM used) Analysis of data from the post-ACT implementation period across the fleet revealed that 70% of human error mishaps were connected with aircrew factors, and that 56% of these resulted from at least one CRM failure The authors noted that these percentages were similar to those reported in a separate study prior to ACT implementation Because of a lack of controls or adjustments for potential confounders, no conclusions about effectiveness of the ACT program can be drawn [12]

Comparison to Medicine

Sexton and colleagues compared flight crews with operating room personnel on several measures, including attitudes toward teamwork[19] The study included more than 30,000 cockpit crew members (captains, first officers, and second officers) and 1033 operating room personnel (attending surgeons, attending anesthesiologists, surgical residents, anesthesia residents, surgical nurses, anesthesia nurses) Data from the crew members were obtained from previous administrations of the CMAQ and FMAQ to major airlines around the world (over a 15-year period) The operating room participants were mailed an analogous questionnaire (CMAQ modified[20]), administered over a period of 3 years at 12 teaching and non-teaching hospitals in the United States and abroad (Italy, Germany, Switzerland, and Israel)

The level of teamwork perceived by attending surgeons compared with other operating room staff differed markedly A majority of surgical residents (73%) and attending surgeons (64%) reported high levels of teamwork, but only 39% of attending anesthesiologists, 28% of surgical nurses, 25% of anesthesia nurses, and 10% of anesthesia residents reported high levels of teamwork A bare majority (55%) of attending surgeons rejected steep hierarchies (determined by whether they thought junior team members should question the decisions of senior team members) In contrast, 94% of airline crew members preferred flat hierarchies

It was also noted that medical participants were far more likely to agree with the statement "Even when fatigued, I perform effectively during critical times " Seventy percent of attending surgeons agreed with this statement, as well as 56% of surgical residents, 60% of surgical nurses, 57% of anesthesia residents, 55% of anesthesia nurses, and 47% of attending anesthesiologists In contrast, 26% of pilots agreed with this statement

Applications of CRM Principles in Medicine

The Sexton study and other analyses suggest that safety-related behaviors that have been applied and studied extensively in the aviation industry may also be relevant in health care We identified CRM applications in several dynamic decision-making health care environments the operating room, labor and delivery, and the emergency room[3,21,22] In addition, Gaba has noted that some other domains (eg, cardiac arrest response teams) that have active simulation training are currently incorporating a broader range of CRM-like training methods[23] (Simulators are covered in more detail in Chapter 45)

Practice Description

Crew Resource Management in Health Care Settings

As with aviation, the medical application of CRM has required tailoring of training approaches to mirror the areas in which human factors contribute to mishaps In anesthesiology 65-70% of safety problems (accidents or incidents) have been attributed at least in part to human error In response, several anesthesiologists from the VA Palo Alto Health Care System and Stanford University, with funding from the Anesthesia Patient Safety Foundation, developed *Anesthesia Crisis Resource Management* (ACRM), modeled on CRM[3 23] The original demonstration courses consisted of didactic instruction, videotape of a reenactment of an aviation disaster, videotape of an actual anesthetic mishap, simulation training and a debriefing session Ongoing courses include the use of a textbook that catalogues 83 critical events (eg, acute hemorrhage, bronchospasm, seizures), and approaches to managing them[24] Currently, there are 3 ACRM courses offering progressively more challenging material, a Working Group on Crisis Management Training in Health Care formed by the developers of ACRM that has initiated formal ACRM instructor training, and thoughtful consideration of pragmatic approaches to evaluating ACRM[23]

Helmreich and Schaefer have also advanced CRM theory in the operating room environment by adapting their model of team performance This framework describes the team performance inputs that are critical to essential team functions that in turn lead to desired outcomes (defined as patient well-being) Examples of inputs include individual aptitudes, physical environment, and culture (professional, organizational, and national) Performance functions consist of team formation and management, surgical procedures, communications, decision processes, and situational awareness[18]

Another application of CRM to the health environment is the *MedTeams behavior-based teamwork system*, developed by Dynamics Research Corporation, and sponsored by the Army Research Laboratory It aims to adapt research in team performance and training from military helicopter aviation to emergency medicine[22,25,26] Thus far, specific applications have been developed for Emergency Department care and labor and delivery units[27] The system is implemented through courses and assessment tools The Emergency Team Coordination Course (ETCC) includes 5 team dimensions or goals (ie, maintain team structure and climate, facilitate planning and problem-solving, enhance communication among team members, facilitate workload management, improve team-building skills) Each goal is tied to specific teamwork tasks For example, tasks for the first goal (maintain team structure and climate) include “establish team leader,” “form the team,” “set team goals,” and “assign roles and responsibilities”[22] Like the CRM approach to the “Error Troika,” the MedTeams approach is based on avoiding errors, trapping them as they occur, and mitigating the consequences of actual errors Principles underlying the MedTeams approach include

- Team responsibility for patients
- A belief in clinician fallibility
- Peer monitoring
- Team member awareness of patient status, team member status and institutional resources

Peer monitoring is a fundamental component of the MedTeams system, as well as a feature of the ACRM and aviation field’s CRM approaches Along with his or her clinical responsibilities, each team member undertakes the intermittent process of peer monitoring or "check" actions, engaging in this check cycle as frequently as possible The teamwork check cycle begins with each team member monitoring his or her own situation awareness and cross-monitoring the actions of other teammates If during the monitoring mode the *monitoring* teammate observes a suspected error in progress, that individual intervenes with a direct question or offer of information The erring teammate may then acknowledge the lapse, correct it and continue working Alternatively, the *monitoring* teammate may have lost situation awareness The non-erring *monitored* colleague can then provide feedback to correct the peer's situation awareness If team members are in strong disagreement about how patient care should proceed, advocacy, assertion and perhaps third-party involvement may be used to resolve the situation Over time, the check cycle becomes habitual, resulting in hundreds of team checks daily, all with the potential to break the error chain

Recently, ACRM has been extended to a full-day course on neonatal resuscitation training for neonatologists and pediatricians[21] Called “NeoSim”, the course combines traditional training methods with reviews of literature and didactic instruction with simulation. Debriefing follows, using videotape of the simulation. As with the other examples, the emphasis of teaching behavioral teamwork skills along with technical content is the hallmark of CRM interventions in health care.

Evidence for Effectiveness of the Practice

The most thoroughly studied of the medical CRM applications is ACRM, although as with the aviation examples, rigorous evaluations are challenging to design. Few studies utilize a control group, although researchers have reported assessment methods for determining both technical and behavioral performance from simulator videotapes[28] (see also Chapter 45). A before-after ACRM training analysis (Level 3 Study Design) of trainees' knowledge-base (Level 3 Outcome) for crisis yielded mixed results.[3] The average score on the post-test was significantly greater than the pre-test for one trainee class, composed mostly of residents. For the other class of experienced anesthesiologists, the test scores did not change and were at the same level as the post-test scores of class of residents. Subjective data evaluating the course indicated that trainees "uniformly felt that the ACRM course was an intense, superior form of training related to an important, but inadequately taught, component of anesthesia practice."[3] Another study of ACRM at Harvard also found that participants rated the course favorably, with over 80% responding that they felt the course should be taken every 24 months or less.[29]

As with aviation, the incremental value of this form of training is difficult to link to improvements in teamwork performance and better safety records. At the time of this literature assessment, there were no published data to describe the effects on medical error rates of the MedTeams approach. The NeoSim course participants provided positive responses to open-ended questions about their satisfaction with the course.[21]

Costs and Implementation

Helmreich has noted some of the limitations associated with CRM.[10] At this time, the evidence connecting CRM approaches to improving patient safety does not exist, notwithstanding the face validity of the approach. Nevertheless, a long history of variants of the approach offers health care a reasonable foundation from which to draw practical and evidenced-based resources[30] for further development and adaptation of CRM, as well as measurement methods to ascertain its effectiveness.

At a minimum, implementation of the CRM approach in health care settings requires customization of tools and techniques for each specific care venue, as is illustrated by adaptations implemented thus far. This customization comes at considerable cost and cannot be expected to immediately reap safety benefits. At the time of this review, approximate costs for implementing the MedTeams system ranged from $15,000-$35,000, with additional costs for ongoing activities (such as continuing education) that ranged from $8,000-$20,000 (R. Simon, personal communication, April 2001). Similarly, marginal costs for CRM-like training based on the ACRM experience are estimated at $800 to $2,000 per participant per day (D. M. Gaba, personal communication, June 2001). These costs do not include the overhead of starting a program (eg, simulator investment, training instructors), nor do they factor in the cost of reduced practice work hours, if these are above those devoted to current training time.

Cultural shifts in medicine are also necessary if the CRM approach is truly to take root. CRM applications are relatively novel in health care, a field in which professional training and education have traditionally focused on developing technical proficiency rather than facilitating human interaction. Although communication and decision making are central to medical practice, relatively little about this topic has appeared in medical literature, despite the fact that information flow is critical, particularly in high acuity venues such as the operating room and emergency departments Ideas must be elicited, debated and evaluated without discrimination based on the status of the staff person offering the information [31]

Paradoxically, the attachment to hierarchy may be the reason that a small percentage of participants can be expected to reject CRM training Research has shown that some resistance is rooted in personality characteristics Crew members lacking in achievement motivation and interpersonal skills are more likely to reject the training Additionally, CRM practices decay over time, even with repeated training, requiring continuing expenditures to retain the hoped-for gains [10]

Comment

CRM has evolved in the airline industry for more than 20 years, and has been extensively applied during the past decade Although no definitive data link CRM to decreased aviation error *per se,* the industry has accepted the face validity of the practice, and it is now an integral part of training Over time, survey data from thousands of civilian and military participants in the United States and abroad has been accrued These data indicate that most flight crew members accept CRM training, and find it both relevant and useful [7]

The studies reviewed provide some support for the notion that CRM is worth further investigation in health care However, it cannot yet be concluded that CRM is a practice that can reduce medical errors Additional research in this area is warranted, although measurement and study design are particularly challenging As noted, although the evidence from aviation, where CRM is well-established, has shortcomings, data are easier to capture since CRM assessments can be grafted onto mandatory, ongoing, yearly pilot assessments conducted both in simulators and in real flights (D M Gaba, personal communication, June 2001) In medicine, where ongoing assessments are not the norm, capturing relevant data will be more difficult logistically and much more expensive than in aviation Consequently, and for the analogous reasons that aviation has adopted CRM based on face validity, health care decision makers may wish to consider face validity in lieu of massive research investments

Nonetheless, evaluations of CRM that focus on intermediate outcomes (eg, trainee performance) are feasible, and instructive for optimizing components of CRM programs CRM design and evaluation resources are becoming more widely available,[30] and health care should continue to consult these sources, building on the advances made in other fields

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第44章　クルー資源管理とその医学への応用

原著のこの章へ

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背景

技術的に複雑でリスクの大きい他の分野と同しように、患者の介護は、異なる役割と意志決定責任をもった高等の技術訓練を受けた個人からなるチームによって進められる相互依存プロセスである。技術訓練は特定の仕事に確実に熟達させるか、流動的な環境のなかでコミュニケーションと意志決定によって生み出される過誤の潜在性に対処するものではない。航空業界の専門家はクルー資源管理と呼ばれる効果的なチーム管理に焦点を当てた安全訓練を開発してきた。民間航空業界の安全記録の改善は1つにはこの訓練のおかげであると言ってよい[1]。過去10年以上にわたって、チーム訓練に対する航空業界のアプローチから得られた教訓は患者の安全性、特に、集中治療室と麻酔訓練における患者の安全性に応用されてきた[2,3]。本章では操縦室資源管理とも呼ばれるクルー資源管理に関する文献をレビューし、この訓練の枠組みの医学への適合性を検討する。

安全方策

航空業界のクルー資源管理

クルー資源管理は運航クルーの操縦を改善するために広範に利用されてきた。その概念は、航空機墜落で人間の過誤が果たす役割を検証したNASAのワークショップに応える形で1979年に生まれた[4]。クルー資源管理はストレスとリスクの大きい環境における人間要素の役割を強調している。国家輸送安全委員会の委員で心理学者のJohn K Lauberは、クルー資源管理を「安全で効率的な航空機の操縦を達成するために利用できるあらゆる源泉－情報、機器、人間－を利用すること」と定義している[5,6]。クルー資源管理にはチーム訓練のほかにシミュレーション（*実際の航空路の運航を指向した飛行訓練*—LOFT—とも呼ばれている）、グループによる対話式の反省、運航クルーの技能の測定と改善が含まれている。

普遍的なクルー資源管理訓練プログラムはない。連邦航空局（FAA）は航空会社がそれぞれの組織のニーズに最適になるようにクルー資源管理プログラムを個別調整するのを認めている。したがって、訓練プログラムは航空会社によって多少異なっており、そのため実際の構成要素を説明するのは困難である。さらに、これらのプログラムは、航空技術の変化および集団力学で次々にわかってきたことに合わせて進化し続けている。

1つのクルー資源管理モデルが人間の有効性という要素に焦点を当てている[7]。効果的なクルー管理の3つの主要構成要素は、安全性、効率性、士気である。運航クルーの目標達成機能に関係する特定の要素は分類され、訓練と研究のための基盤となっている。これらの要素には、目標達成機能に関係する資材、組織、個人、グループ　プロセスの変数が含

まれている[8]。これらの入力変数から生まれるアウトカムの例として安全性、効率性、顧客満足度などがある。

その後、Helmreich らは修正されたクルー資源管理の概念的枠組みを提唱した。これは過誤対策の 3 つのレベルを強調するために「エラー・トロイカ」[9]と名付けられている。クルー資源管理の第 1 レベルには、過誤の回避の仕方に関する訓練が含まれている。第 2 レベルでは、潜在的な過誤が顕現する前にそれらを「捕捉」する。第 3 レベルでは、過誤の重大さを軽減する。

実際的な観点から、クルー資源管理には人間の目標達成機能の限界に関する教育クルーが含まれているのがふつうである[10]。訓練生は、認知過誤、およびストレッサー（疲労、緊急事態、作業の過負荷など）が過誤の発生にどのようにかかわっているのかということについて理解を深める。数日にわたるクルー資源管理訓練プログラムでは、ふつう、参加者は個人行動とチーム行動の検討評価を求められる。強調されている運航概念には、問い質し、関係する運航情報を求めること、支持、予定されている措置を伝えること、摩擦解消、意志決定が含まれている。

対象となる安全性問題の広がりと重要性

航空分野は安全性関係データの収集と分析についてかなりの実績をもっている。歴史的には、人間の過誤が航空事故の 50%以上を引き起こしたり、その一因となってきたりしている。7 年半にわたる 3 万 5000 件の事故報告書の分析では、約 50%が運航クルーの過誤が原因であり、さらに 35%が航空管制官の過誤が原因だった[11]。安全専門家による根本原因分析（第 5 章）は、運航クルーが自分たちに利用できる資源の効果的な管理を怠る（たとえば、情報に不明な点がある場合にその確認を怠る、不測の事態への備えを怠る）せいで過誤が頻発することを見出した[11]。海軍航空隊の報告書も同様な結果を示しており、1 つの研究は「クラス A の事故」（死亡、機体損壊、重傷を含む重大な結果となった事故）の 59%が、ある程度運航クルーの要素に帰せられると報告している[12]。これらの分析や同様の分析は、民間航空のためのクルー資源管理、および海軍クルーのための「運航クルー調整訓練」[12]を含むそれぞれのニーズに合った過誤防止方策を生む触媒となっている。

研究デザインと結果

尺度

クルー資源管理の有効性の最も明確で意味のある尺度は航空会社の事故率や「ニアミス」率だと思われるが、この客観的な尺度は民間航空の研究では使われてこなかった。Helmreich は、事故率が大変小さく、「ニアミス」が自己申告なので、これらの尺度は使えないと指摘している[10]。さらに、クルー資源管理訓練プログラムの内容と構成は変わりやすい[10]。

そこで、研究者たちは他の仕方でクルー資源管理の有効性を評価する手段を開発してきた。これらの手段には、NASA／テキサス大学 Line／LOS チェックリスト（LINE／LOS チェックリスト）[13]を含む個人的な意見の調査と目標達成機能同僚評価アンケート、操縦室管理姿勢アンケート、飛行管理姿勢アンケートが含まれている。LINE／LOS チェックリス

トは、飛行の特定の部分における決定的に重要な行動（たとえば、ブリーフィングを省略しない、作業負荷が高い場合にも低い場合にも高水準の用心を示すなど）に関するクルーの目標達成機能を評価するために使われている。各行動要素（すなわちチームワークのためのモデル）の評価は、「悪い」から「きわめてよい」まで4段階に分かれている。

対照的に、操縦室管理姿勢アンケートはクルー資源管理訓練の前と後に、組織の内部および組織間のクルーメンバーの姿勢を評価するために使われている。結果はクルーの手順と目標達成機能を測定するための代用アウトカムとして役立てられる[14]。この手段は、自己申告の姿勢を、同僚評価の訓練を受けた専門家である審査運航乗務員による目標達成機能評価と比較することによって妥当性が確認されてきた[15]。飛行管理姿勢アンケートは、さまざまな国の運航クルーに観察された姿勢の相違を勘案して Helmreich らが開発した、操縦室管理姿勢アンケートの改定版である[16]。

飛行シミュレーションにおける運航乗務員の目標達成機能の観察も利用されてきた。

代表的な研究

いくつかの研究がクルー資源管理の有効性を検証するための代用手段を利用している[8,12,17]。Helmreich らによる1つの研究は、クルー資源管理訓練の前と後の姿勢の評価（事前テスト対事後テスト）で構成されている[17]。訓練を受けた観察者が NASA／テキサス大学 Line／LOS チェックリストを使ってクルーの行動を書きとめる[18]。この分析には、2000回以上の実際の航空路での飛行訓練と LOFT 訓練が含まれている。クルーの全体的な目標達成機能は審査運航乗務員や LOFT 教官によって「平均より下」、「平均」、「平均より上」に評価されている。

クルー資源管理訓練の結果として「平均より上」と評価されたクルーの割合が増加し、「平均より下」と評価されたクルーの割合が減少している。目標達成機能の評価は海軍と民間航空会社の間で異なっている。また、優れたパイロットは多くの姿勢を共有している（たとえば、自分の個人的限界や緊急事態の際の意志決定能力の減退を承知している）。さらに、彼らは他のクルーメンバーに対して自分の意志決定や措置に疑問があれば質問するように奨励し、他のクルーメンバーの個人的な問題に敏感であり、計画を口に出して述べたり他のクルーメンバーを訓練したりする必要があることを認識している。

Barker らによる2つめの研究は、クルー資源管理訓練を受けた17のクルーを「固定」クルーと「寄せ集め」クルーに分けて、軍用飛行シミュレーターでクルーの有効性を比較している[8]。9つのクルーはメンバーが6か月以上にわたって一緒に飛行していたので「固定」クルーとされ、残りの8つは一緒に飛行していたのが6か月未満だったので「寄せ集め」クルーとされてシミュレーションに参加した。飛行の第1行程は何の問題もないようにプログラムされていたが、第2行程ではクルーが1つの安全性問題に対処しなければならないようになっていた。前述の研究の場合と同じように、NASA／テキサス大学 Line／LOS チェックリストを使ってクルーの行動を観察している。驚いたことに、寄せ集めクルーの方が小さな過誤の数が少なく、しかも両グループで大きな過誤の数にそれほど違いがなかったのである[8]。Barker らは、寄せ集めクルーの方が固定クルーより無駄のない協調努力をしていたと思われ、それは固定クルーの方が日常的に一緒に仕事をしている慣れによって

無関心になっていた可能性があるからだが、さらに調査か必要たと結論づけている。

3 つめの研究は、海軍航空隊の事故率およびクルー資源管理がうまくいかなかった場合を検討評価している。この研究は主として 2 種類の装置でクルーの目標達成機能を比較しているが、運航クルーの目標達成機能の欠陥も、運航クルー調整訓練プログラム（使われたクルー資源管理の特定の形態）の実行前の期間中に見られた欠陥と比較している。海軍全体の運行クルー調整訓練実行後の期間のデータの分析は、人間の過誤による事故の 70%が運航クルーの要素と関係があり、これらの 56%が少なくとも 1 つのクルー資源管理がうまくいかなかったことによることを明らかにしている。研究者たちは、これらの割合が運行クルー調整訓練実行前の別の調査て報告されている割合と類似していると指摘している。対照群が設定されていなかったり潜在的な混同要素について調整が施されていなかったりしているので、運行クルー調整訓練プログラムの有効性について何らかの結論を引き出すことはできない[12]。

医学との比較

Sexton らは、チームワークに対する姿勢を含むいくつかの尺度について飛行クルーと手術室要員とを比較している[19]。この研究には 3 万人以上の運航クルーメンバー（料理長、一級機関士、二級機関士）と 1033 人の手術室要員（病院所属外科医、病院所属麻酔医、外科レジデント、麻酔レシデント、手術室看護師、麻酔看護師）が含まれている。クルーメンバーのデータは世界中の主要航空会社を対象にした以前の操縦室管理姿勢アンケートと飛行管理姿勢アンケート（15 年を超える期間にわたる）から入手している。手術室要員の方は、米国と外国（イタリア、トイツ、スイス、イスラエル）の 12 の教育研究病院と非教育研究病院で 3 年間にわたって郵送による類似のアンケート（操縦室管理姿勢アンケートを改変したもの[20]）を行っている。

病院所属外科医が感じているチームワーク水準は他の手術室要員と著しく異なっている。チームワークが高い水準にあると回答している割合は、外科レジデントが 73%、病院所属外科医が 64%と大半を占めているが、病院所属麻酔医は 39%、手術室看護師は 28%、麻酔看護師は 25%、麻酔レシデントは 10%だけである。厳しい上下関係を否定している病院所属外科医（彼らが、チームの下位メンバーであっても上位メンバーの決定に疑問があれば質問すべきだと考えているかどうかで判断）は半分強（55%）にとどまっている。対照的に、飛行クルーのメンバーの 94%は横並びの関係を好んでいる。

また、手術室要員の方が「たとえ疲れていても、私はきわめて重要な際には、効果的に機能を遂行する」という文に同意する傾向がはるかに強いことか指摘されている。病院所属外科医の 70%、外科レシデントの 56%、手術室看護師の 60%、麻酔レシデントの 57%、麻酔看護師の 55%、病院所属麻酔医の 47%かこの文に同意している。対照的にパイロットは 26%にとどまっている。

医療環境におけるクルー資源管理原則

Sexton の研究や他の分析は、航空業界て広範に応用され、研究されてきた安全性関連の行動か医療分野でも意味かあると思われることを示唆している。私たちは、手術室、分娩、緊急処置室という、いくつかの流動的な医療意志決定環境におけるクルー資源管理の応用