Error, stress, and teamwork in medicine and aviation: cross sectional surveys

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Abstract

Objectives: To survey operating theatre and intensive care unit staff about attitudes concerning error, stress, and teamwork and to compare these attitudes with those of airline cockpit crew.
Design: Cross sectional surveys.
Setting: Urban teaching and non-teaching hospitals in the United States, Israel, Germany, Switzerland, and Italy. Major airlines around the world.
Participants: 1033 doctors, nurses, fellows, and residents working in operating theatres and intensive care units and over 30 000 cockpit crew members (captains, first officers, and second officers).
Main outcome measures: Perceptions of error, stress, and teamwork.
Results: Pilots were least likely to deny the effects of fatigue on performance (26% *v* 70% of consultant surgeons and 47% of consultant anaesthetists). Most pilots (97%) and intensive care staff (94%) rejected steep hierarchies (in which senior team members are not open to input from junior members), but only 55% of consultant surgeons rejected such hierarchies. High levels of teamwork with consultant surgeons were reported by 73% of surgical residents, 64% of consultant surgeons, 39% of anaesthesia consultants, 28% of surgical nurses, 25% of anaesthetic nurses, and 10% of anaesthetic residents. Only a third of staff reported that errors are handled appropriately at their hospital. A third of intensive care staff did not acknowledge that they make errors. Over half of intensive care staff reported that they find it difficult to discuss mistakes.
Conclusions: Medical staff reported that error is important but difficult to discuss and not handled well in their hospital. Barriers to discussing error are more important since medical staff seem to deny the effect of stress and fatigue on performance. Further problems include differing perceptions of teamwork among team members and reluctance of senior theatre staff to accept input from junior members.

Introduction

Population based research suggests that in the United States between 44 000 and 98 000 patients die each year from preventable errors, making medical error the eighth most common cause of death.[1–3] Research in safety critical industries tells us that to overcome this problem we must understand the system used to deliver care.[4 5]

Adoption of a systems approach to improvement means acknowledging the limitations of technological solutions. Other components of healthcare delivery systems, such as professional and organisational cultural factors (for example, denial of vulnerability to stress) and interpersonal aspects of performance (for example, lack of teamwork within and between disciplines), therefore also need to be studied to increase the understanding of and prevent errors.[6] One of the better established (yet often overlooked) findings in stress research is that as stress or arousal increases, an individual's thought processes and breadth of attention narrow.[7 8] Poor teamwork and communication have been documented during trauma resuscitation,[9 10] surgical procedures,[11 12] and treatment of patients in intensive care units.[13] One systems approach to medical error has led to the development of simulators to study and improve teamwork for surgical and trauma resuscitation teams.[14–16] Further research is needed to tailor such training to the specific needs of individual organisations.

The airline industry has used surveys to collect data on pilot attitudes about safety and interpersonal interactions to diagnose strengths and weaknesses and to aid in the development of interventions. Individuals' attitudes (as opposed to personalities) are relatively malleable to training interventions[17] and predict performance.[18] A successful intervention called crew resource management training has been developed to address specific attitudes, change related behaviour, and improve performance of the cockpit crew.[19] Correspondingly, attitudes about errors, teamwork, and the effect of stress and fatigue on performance could be prime targets for measurement and improvement in medicine. Surveys are an inexpensive method of data collection that points to interventions and fit well with the systems approach since they elicit (on a large scale) what caregivers actually think.

For the past 20 years, the University of Texas human factors research project has been investigating teams at work in safety critical environments such as aviation, space, maritime, and medicine. In this paper, we present recent data comparing attitudes about error, stress, and teamwork among healthcare workers and airline cockpit crew members. We also present error related perceptions of intensive care doctors and nurses. Aviation data are presented to serve as a point of reference from another safety critical domain.

The survey items presented tap into attitudes toward stress, hierarchy, teamwork, and error. Previous research has found that these items are relevant to understanding error,[20] predictive of performance,[18] and sensitive to training interventions.[17 21 22] Attitudes regarding the recognition of stressor effects indicate the degree to which individuals will place themselves in error inducing conditions, and items regarding hierarchy and teamwork indicate the abilities of team members to manage both threats and errors in a team environment.

Participants and methods

We used four questionnaires to survey participants. The cockpit management attitudes questionnaire has been widely used in aviation and was developed to measure attitudes toward stress, status hierarchies,

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Responses to questions on dealing with stress and teamwork according to discipline and position. Values are numbers (percentages)

	Anaesthetic			Surgical			Intensive care		
Item description	Nurse (n=162)	Resident (n=60)	Consultant (n=104)	Nurse (n=175)	Resident (n=52)	Consultant (n=167)	Registered nurse (n=109)	Consultant or fellow (n=31)	Pilots (n=7558)
Even when fatigued, I perform effectively during critical phases of operations/patient care									
Agree	89 (55)	34 (57)	49 (47)	105 (60)	29 (56)	117 (70)	70 (64)	20 (64)	1965 (26)
Neutral	36 (22)	6 (10)	16 (15)	30 (17)	6 (11)	20 (12)	6 (6)	4 (13)	756 (10)
Disagree	37 (23)	20 (33)	39 (38)	40 (23)	17 (33)	30 (18)	33 (30)	7 (23)	4837 (64)
A truly professional team member can leave personal problems behind when working in the operating room/intensive care unit									
Agree	96 (59)	33 (55)	55 (53)	122 (70)	33 (63)	137 (82)	76 (70)	21 (68)	4005 (53)
Neutral	24 (15)	8 (13)	10 (10)	16 (9)	5 (10)	17 (10)	11 (10)	7 (22)	680 (9)
Disagree	42 (26)	19 (32)	38 (37)	37 (21)	14 (27)	13 (8)	22 (20)	3 (10)	2872 (38)
My decision making ability is as good in medical emergencies as in routine situations									
Agree	91 (56)	37 (61)	70 (67)	126 (72)	30 (58)	127 (76)	91 (84)	28 (90)	4837 (64)
Neutral	49 (30)	10 (17)	10 (10)	33 (19)	12 (23)	22 (13)	6 (5)	0	907 (12)
Disagree	23 (14)	13 (22)	24 (23)	16 (9)	10 (19)	18 (11)	12 (11)	3 (10)	1814 (24)
Junior team members should not question the decisions made by senior team members									
Agree	21 (13)	9 (15)	17 (16)	24 (14)	11 (21)	40 (24)	2 (2)	1 (3)	151 (2)
Neutral	27 (17)	8 (13)	10 (10)	30 (17)	11 (21)	35 (21)	4 (4)	1 (3)	76 (1)
Disagree	113 (70)	43 (72)	87 (84)	121 (69)	30 (58)	92 (55)	102 (94)	29 (94)	7331 (97)

leadership, and interpersonal interaction issues.[23] The questionnaire is reliable, sensitive to change,[22] and the elicited attitudes have been shown to predict performance.[18 24] A subsequent version, the flight management attitudes questionnaire,[25] was developed to broaden the perspective of the instrument to include the effect of organisational climate and national culture on safety.

Two medical surveys have also been developed as part of an extension of human factors research into medical environments: the operating room management attitudes questionnaire[11] and the intensive care unit management attitudes questionnaire, which is reported here for the first time. All the questionnaires contained a core set of 23 items from the cockpit management attitudes questionnaire with minor modification of wording to match the work environment—for example, "Junior cockpit crew members should not question the decisions made by senior cockpit crew members" was changed to "Junior operating room team members should not question the decisions made by senior team members." These core items allow comparisons to be made over time, across different organisations, across positions within an organisation (such as nurses and doctors), and between disciplines. We report here results of the core items as well as a set of error related items specific to the intensive care questionnaire.

All surveys were administered through hospital or airline internal mail (with parallel covering letters). Respondents were given the option of returning their questionnaires in an anonymous drop box or a stamped envelope addressed to our laboratory in Austin, Texas. In each administration, the survey content was essentially the same.

The core items have been administered to cockpit crew members (captains and first and second officers) from 40 different airlines in 25 countries over 15 years (with the flight management attitudes questionnaire used in the past seven years). The operating room questionnaire was completed by theatre staff (surgical and anaesthetic consultants, nurses, and residents) from 12 urban teaching and non-teaching hospitals in Italy, Germany, Switzerland, Israel, and the United States in the past three years. The intensive care data are from staff in one large urban teaching hospital in the United States. The respondents were intensive care physicians (adult and child pulmonary physicians, cardiologists, and neonatologists) and nurses (registered nurses, licensed vocational nurses).

Statistical analysis

Data from each of the surveys were merged into a combined database of operating theatre, intensive care, and flight crews. Data from each of the staff positions were collapsed across all hospitals with representative samples. We excluded two hospitals from the analyses because they did not provide representative samples. We have presented descriptive data, as the sample size is not large enough for multilevel modelling.

Results

The flight management questionnaire and cockpit management questionnaire were returned by over 30 000 pilots, with response rates ranging from 15% to over 90% (average 45%). The operating room questionnaire was returned by 851 staff (response rate 40% to 100%) and the intensive care questionnaire by 182 staff (response rate 59%). In an effort to make the medical and aviation samples roughly equivalent, pilot data from Latin America and Asia, which were not sampled in medicine, were not included.

Perceptions of stress and fatigue

In response to the item, "Even when fatigued, I perform effectively during critical times," 60% of all medical respondents agreed, ranging from 70% among consultant surgeons to 47% among consultant anaesthetists (table). The rate of agreement was much higher in medicine than in aviation (26% of pilots agreed). As there were no differences between captains, first officers, and second officers the data are not presented separately.

Sixty seven per cent of respondents believed that true professionals can leave personal problems behind when working. Pilots and anaesthesia consultants, residents, and nurses were less likely to deny the effects of

personal problems (53%-59%) than surgical consultants (82%). In response to the item, "My decision making ability is as good in medical emergencies as in routine situations," 70% of all medical respondents agreed. Among theatre staff, consultant surgeons were the most likely to agree with this statement, and intensive care staff were more likely to agree than surgeons (table). In general, only a minority of respondents openly recognised the effects of stress on performance.

Attitudes to teamwork and hierarchy

Seventy per cent of respondents did not agree that junior team members should not question the decisions made by senior team members, but there were differences with position and discipline (table). Consultant surgeons were least likely to advocate flat hierarchies (55%). By contrast, 94% of cockpit and intensive care staff advocated flat hierarchies.

Over 80% of all medical staff reported that preoperative and postoperative discussions (for intensive care staff before and after ward rounds) are an important part of safety and teamwork. A quarter indicated that they are not encouraged to report safety concerns, and only a third said that errors are handled appropriately in their hospital.

Differing perspectives of teamwork in medicine

The different perspectives on teamwork among medical staff were shown by the responses to the item "Rate the quality of teamwork and communication or cooperation with consultant surgeons" (fig 1). In particular, surgical consultants and residents rated the teamwork they experienced with other consultant surgeons the highest (64% (29/45) and 73% (40-55) reported high levels of teamwork; 7% (3/45) and 9% (5/55) reported low levels), while anaesthesia residents, anaesthesia nurses, and surgical nurses rated interactions with consultant surgeons lowest (10% (8/77), 26% (36/141), and 28% (35/124) reported high levels of teamwork; 39% (48/124), 43% (33/77), and 48% (67/141) reported low levels). At the aggregate level, 62% (146/135) of surgical staff rated teamwork with anaesthesia staff highly, and 41% (106/250) of anaesthesia staff rated teamwork with surgical staff highly. In other words, surgery generally reports good teamwork with anaesthesia, but anaesthesia staff do not necessarily hold a reciprocal perception.

Differences between doctors and nurses were found regarding the quality of teamwork in intensive care. Although 77% of intensive care doctors reported high levels of teamwork with nurses, only 40% of nurses reported high levels of teamwork with doctors.

Attitudes about error and safety

Over 94% of intensive care staff disagreed with the statement "Errors committed during patient management are not important, as long as the patient improves." A further 90% believed that "a confidential reporting system that documents medical errors is important for patient safety." Over 80% of intensive care staff reported that the culture in their unit makes it easy to ask questions when there is something they don't understand (this is undoubtedly related to the high endorsement of flat hierarchies in the unit). One out of three intensive care respondents did not acknowledge that they make errors. Over half report that decision making should include more team member input.

More than half of the respondents reported that they find it difficult to discuss mistakes, and several barriers to discussing error were acknowledged. The 182 staff in intensive care reported that many errors are neither acknowledged nor discussed because of personal reputation (76%), the threat of malpractice suits (71%), high expectations of the patients' family or society (68%), possible disciplinary actions by licensing boards (64%), threat to job security (63%), and expectations or egos of other team members (61% and 60%). The most common recommendation for improving patient safety in the intensive care unit was to acquire more staff to handle the present workload, whereas the most common recommendation in the operating theatre was to improve communication.

Discussion

Historically, medical and aviation workers have been expected to function without error.[6 26 27] In aviation, perceptions of fatigue, stress, and error continue to be topics of training and targets for improvement. Much progress has been made to create a culture in aviation that deals effectively with error, whereas in medicine substantial pressures still exist to cover up mistakes, thereby overlooking opportunities for improvement. We found that susceptibility to error is not universally acknowledged by medical staff, and many report that error is not handled appropriately in their hospital.

Medical staff also play down the effects of stress and fatigue. The denial of stress and its effects on performance may help individuals adapt to medical school and residency, but a healthy recognition of stressor effects reduces the likelihood of error[20] and increases the use of threat and error management strategies. For instance, tired pilots who acknowledge their own limitations manage their fatigue by saying that they are tired, asking other crew members to keep an eye on them, increasing caffeine intake, and reallocating workload as necessary during the flight. Many tragedies, such as flying accidents, military defeats, and recent incidents on the space station MIR, are linked to the failure of individuals to perform appropriate well rehearsed actions under stress.[28] Research in aviation

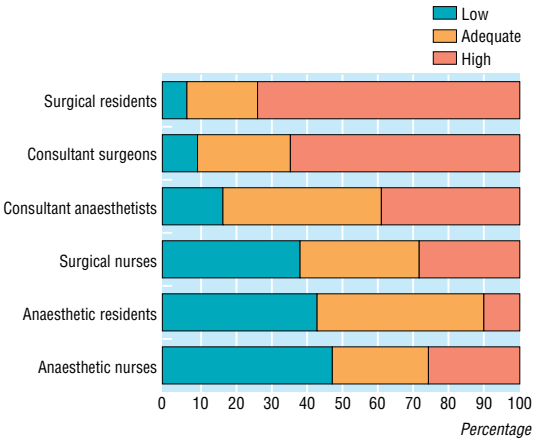

Fig 1 Rating of teamwork with consultant surgeons

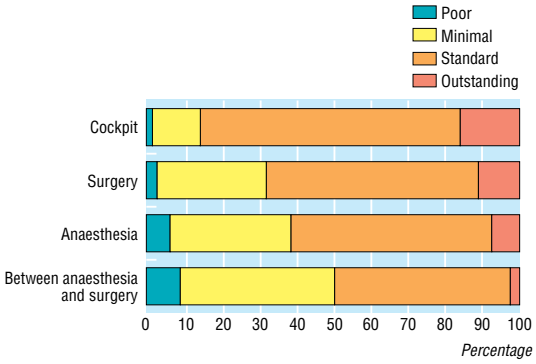

Fig 2 Trained observers' ratings of teamwork in aviation, surgery, anaesthesia, and between surgery and anaesthesia

shows that individuals can be trained to recognise stress as an error inducer—for example, by crew resource management training[21]—and continue to improve with recurrent training.[29]

Measuring teamwork attitudes and behaviour

Ratings of teamwork and communication differed substantially among groups of respondents. The perception of poor teamwork by one team member, whether actual or perceived, is enough to change the dynamics within that team, causing that team member to withdraw. Preliminary data from behavioural observations of teamwork by trained observers of operating theatre teams suggest that these attitudes are representative of behaviour (particularly with respect to teamwork between surgical and anaesthetic staff; fig 2).[12 27 30] Future research should investigate teamwork in medicine, and its relationship to error rates and error severity. In addition to being an error-management technique, effective teamwork and communication also has several positive side effects, such as fewer and shorter delays, and increases in morale, job satisfaction, and efficiency. Behaviour was observed in 3204 commercial flights, from before departure to landing, and in 96 randomly selected surgical procedures from patient arrival to transfer to the recovery room. Examples of a poor rating would be failed communication of skin incision or removal of the aortic-cross clamp or implementation of Trendleburg position without notifying the surgeon.

There is a relationship between perceptions of teamwork and status in the team. Surgeons are most supportive of steep hierarchies in which junior staff do not question senior staff. Surgeons also perceive teamwork and communication in the team to be of a higher quality than the rest of the team. Similarly, in intensive care, doctors rated teamwork with nurses higher than did nurses with doctors. However, future research should not focus exclusively on consultants. Indeed, our experience in aviation tells us that poor communication does not equate to an obstinate captain but to poor threat and error management at the team level. Highly effective cockpit crews use one third of their communications to discuss threats and errors in their environment, regardless of their workload, whereas poor performing teams spend about 5% of their time doing the same.[31]

Limitations

The most important limitation of our study was the small sample of hospitals, and these data should therefore be considered preliminary. As more data are collected, the issues of hospital to hospital variation and non-response biases can be addressed empirically. Our research in aviation found no significant differences between cockpit crew responders and non-responders on demographic variables such as sex, years experience, background (military or civilian), and position (captain, first officer, second officer).

Survey data are limited by reliance on self reporting, are potentially biased by non-responders (little is known about non-response biases in healthcare surveys such as these), and are not the panacea for what ails a safety critical system. However, they can be used to diagnose the strengths and weaknesses of an organisation, to create data driven training interventions, and to assess the effect of training. Survey data also help to tailor training interventions to address local issues.

Changing the professional culture in aviation

After the introduction of jet transport in the 1950s, accident rates due to mechanical failure dropped steeply. As data on accidents accumulated, it became obvious that most accidents were related to breakdowns in crew coordination, communication, and decision making. The resulting shift toward a more open culture that accommodated questioning and recognised human limitations was a gradual but steady progression.

The change came about through the involvement of the research community, National Aeronautics and Space Administration, regulatory agencies, and the use of data driven initiatives to raise awareness of the limitations of human performance and the importance of effective teamwork. For the first time there were instruments to collect reliable human factors data—a combination of individual attitudes, organisational norms, and assessments of behaviour before and after training interventions determined if change was actually taking place without having to rely on retrospective data from accident investigation. Data collection instruments such as the cockpit management attitudes questionnaire were used to show changes in safety related attitudes before and after training, and these changes mapped on to actual behaviour in the cockpit.[19]

Selection and training processes were amended. Pilots began to be selected not only for technical skills but also their ability to coordinate activities, learn from error, and recognise that others can contribute to problem solving. Airlines initiated a new approach to training and assessing pilot skills by moving away from training the individual pilot to training the entire crew—recognising that safety and good performance was not just a function of the captain but of the captain using all available resources. The aviation approach is to deal with errors non-punitively and proactively, and this approach defines behavioural strategies taught in crew resource management training (currently in its fifth generation)[32] as error countermeasures that are used to avoid error whenever possible, to trap errors when they do occur,

What is already known on this topic

Much attention has been given to medical error in recent years

No formal studies have compared perceptions of error, stress, and teamwork in medicine and aviation

What this study adds

Medical staff are more likely than aviation staff to deny the effects of stress and fatigue

Cockpit crews and intensive care staff advocate flat hierarchies but surgeons are less likely to do so

Error is difficult to discuss in medicine and not all staff accept personal susceptibility to error

and to mitigate the consequences of error before they escalate into undesirable states.

Much research is needed to gain a full understanding of attitudes and behaviours and their relationship with outcomes in medicine. Although many approaches to team training used in aviation are likely to be useful in medicine, their design and effect need to be fully validated to avoid haphazard approaches of limited utility.

This article is dedicated to the late Dr Hans-Gerhard Schaefer, whose personal quest to find and solve the human problems at the core of medical care made a lasting impression on us. We thank Lou Montgomery and Jennipher Mulhollen for help with administration and data management and Elisa Rhoda for help in collecting the medical data from Italy.

Contributors: JBS (guarantor) coordinated the data collection across hospitals and several of the airlines, formulated the core ideas, and participated in the analyses and writing of the paper. EJT collected data and participated in the analysis and writing. RLH has overseen most of this research since the early 1980s, analysed and interpreted data, and contributed to writing the paper. John Wilhelm has archived all the data collected by the University of Texas human factors research project and also helped in interpretation of the results. Ashleigh Merritt coordinated most of the aviation data collection as part of her dissertation research.

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Endpiece

When I use a word … nice?

Nice—a complimentary acronym you might think. But it originally meant stupid (Latin nescius) and later wanton, strange, lazy, unwilling, or fastidious. By the 16th century it came to mean precise and accurate, but other meanings included slender, trivial, uncertain, and delicate. *Chambers Twentieth Century Dictionary* (1959 edition) lists among possible meanings "calling for very fine discrimination"; "done with great care and exactness"; "accurate"; and then puts the boot in: "used in vague commendation by those who are not nice."

Submitted by Jeff Aronson, clinical pharmacologist, Oxford