TOWARDS AN INTEGRATED SOCIOTECHNICAL FRAMEWORK FOR SITUATION AWARENESS AND DECISION-MAKING FOR EMERGENCY CARE

Harris Abd Hamid[1,2] & Patrick Waterson[1]

[1]*Loughborough University, UK*
[2]*International Islamic University Malaysia, Malaysia*

Emergency Care Practitioner (ECP) is a work role in the Ambulance Services in the UK that was introduced to provide an alternative emergency care within the community. In order to further understand the cognitive aspects of the work role, a study was carried out to identify factors influencing situation awareness and decision-making among ECPs in an Ambulance Service in England. Two ECPs participated in observations (40 hours of ride-outs) and semi-structured interviews. Analysis of the interview reveals factors that can be categorised into a number of systems-related levels of analysis (macro-micro). The outcomes from the study form the basis of an integrated sociotechnical system framework for emergency care with a focus on situation awareness and decision-making.

Introduction

The last few years have seen a huge growth in research focusing on human factors and patient safety. Within this growing body of literature, human factors methods and techniques, and the systems approach in particular, have been used in order to gain a better understanding of human error and decision-making and how these relate to patient safety. A number of specific domains within healthcare have been examined in detail including surgery, anaesthesia, the operation of emergency departments, and the work of ambulance dispatchers. In this paper, we focus on situation awareness (SA) and its relationship with decision-making within the domain of pre-hospital care, specifically the work of advanced ambulance paramedics or Emergency Care Practitioners (ECPs). In the next section, we review research that has examined the relationship between situation awareness and decision-making and their application within healthcare contexts.

Situation awareness (SA) and decision-making

Endsley (1988, p. 97) defined SA as: "…*the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future*". An appropriate level of SA is seen as a requirement for decision-making which in turn affect performance

(Endsley *et al.*, 2003). Decision-making in complex and dynamic work systems requires regular updating of SA. The Naturalistic Decision Making (NDM) approach is well suited for studying the relationship between SA and decision-making (Klein *et al.*, 1993) in applied, dynamic and complex work environments. The Recognition-Primed Decision (RPD) model (Klein *et al.*, 1993), for example, describes how people make decisions quickly by matching the current situation to a pattern they have already learned. Within the RPD model, SA is seen as an important prerequisite in making a decision.

Situation awareness and decision-making within emergency care

Emergency care can be divided into a number of stages, decision-making points (e.g., the decision to transport a patient to hospital as compared to discharging the patient once treatment has been administered by ambulance personnel), types of roles and technological support. Figure 1 shows a simplified pathway for emergency care alongside example of the types of decision-making made by the various personnel associated with stages in the pathway.

The first part of the emergency care pathway in Figure 1 (call taking and dispatch) has been investigated in detail by Blandford and Wong (2004). Their work focused on SA and decision-making among Emergency Medical Dispatch (EMD) operators in the control room of London Ambulance Services. Wong and Blandford (2001) made use of what they termed the "Integrated Decision Model", or IDM (Wong, 2000), to review the decision concepts revealed in studies of ambulance dispatch. The IDM is built upon existing NDM models like the RPD. It describes decision making by highlighting the goal, priorities and constraints, decision process, and SA.

Other work has examined in detail the dynamic and fluctuating nature of emergency care. Anders *et al.* (2006) for example, observed an emergency department within a hospital as the department coped with the challenge of limited resources (e.g., staff shortages) and uncertainties (e.g., quiet and busy periods of activity). They

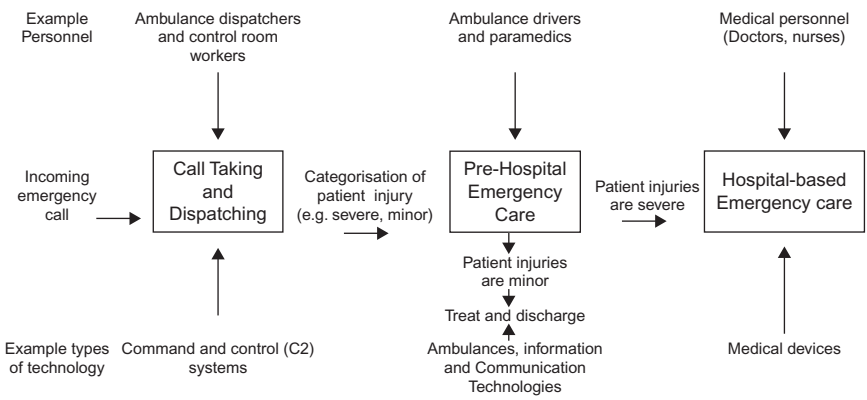

Figure 1. Stages of emergency care pathway.

interpreted their findings as they related to decision-making using a resilience engineering perspective. In general, the emergency department copes with limited resources by reconfiguring spare resources from other departments in the hospital. In some cases this involved allowing paramedics to take over patient care for less critical patients and using the available resources (i.e., doctors and nurses) to attend to more critical cases.

Study aims and objectives

The work of Blandford and Wong (2004; Wong and Blandford, 2001) and Anders *et al.* (2006) provide researchers with an impression of SA and decision-making as it applies to the first (call taking and dispatch) and third parts (hospital-based emergency care) of the pathway described in Figure 1. The main aim of the current paper is to fill in the missing part of the model, namely the process of SA and decision-making as it applies to pre-hospital emergency care. In order to do this we describe a study examining the requirements for SA and decision-making alongside an account of the types of constraints that apply to these processes within this context. A second aim of the paper is to use the findings from the case study to present an outline of an integrated sociotechnical framework for emergency care.

Methods of study

Participants

The advanced paramedics, or ECPs, nominated by the Director of Operations, participated in this study. They are both males aged 39 and 48 with three and one year experience as ECP respectively. Three Triage Nurses working in the ambulance control room also participated in this study.

Procedures

The study adopted a participative observation approach. The observations were performed during the participants' normal working hours. SA related issues were noted and categorised using Endsley's (1988) 3-level classification of SA. The first author followed two ECPs during their regular shift for two shifts each for a total of 40 hours. To increase the probability of attending a variety of patient cases, both day and night shifts were covered during weekdays and weekends.

In addition, two observation sessions on separate days were carried out with three Triage Nurses each lasting four hours. The ECPs were also interviewed using a semi-structured interview schedule, along with one of the Triage Nurses. The primary aim of these interviews was to gain an overview of the operation of the control room and the communication with a focus on the ECP. The findings from the observation and interview sessions were subsequently used to develop a communication map

of the role of the ECP within the Ambulance Services. This map was then validated by a subject matter expert (the Director of Operations for the Ambulance Service).

Findings

Communication between the control room and the Emergency Care Practitioners

Incoming emergency ("999") telephone calls are filtered by Control Room staff and information systems (two medical information systems (MIS1 and MIS2 in Figure 2) and the Advanced Medical Priority Dispatch System (AMPDS) before assigned to ECPs. Calls are taken and information about the patients are gathered to make a decision about the patients' clinical needs. Using the triage system, calls may be passed on to the ECPs by the Triage Nurses. During regular work time, colleagues (ambulance technicians, paramedics) who require assistance may contact the ECPs for their advanced knowledge. In cases where the patient died, the police had to be notified. Additionally the ECP may liaise with other medical services like walk-in health centre, general practitioner's (GP) clinic, District Nurses, and Social Workers.

Situation awareness, decision-making and other factors influencing the work of the Emergency Care Practitioners

Examples of issues that are relevant to SA are presented in Table 1. These issues represent threats to SA. Based on the observations and interviews, five factors were identified as influencing the work of the ECPs. These factors cover both micro and macro levels of the system. The SA issues and five factors are presented in this section.

(1) Targets, levels of resources

National and local standards are set for the ECPs. These standards seem to affect the work assigned to the ECPs. For example, one ECP explains the reason for him being assigned non-ECP type job.

Table 1. Examples of threats to SA by SA levels.

SA Levels	Observation	Inference
Level 1: Perception	The MIS1 screen in the ECP's vehicle displayed truncated postcode	ECP cannot perceive complete information
Level 2: Comprehension	ECP reported that a patient's ECG output is different from what was expected based on pulse pattern	ECP cannot comprehend the contradictory symptoms the patient presented
Level 3: Projection	ECP reported that he wish he know whether the patients are all right after taken by the ambulance to the A&E	ECP cannot make accurate projection of patients' future health condition

"There is an immense pressure at the moment to respond to calls within a certain time and so you're often called in." (ECP2)

Resources allocated for technology also influence the effectiveness of ECPs. The ECP thought that investment should be made with regards to the communication technology (especially the MIS1 and satellite navigation system).

"*The system here is, for some reason, .. they have not fully invested in it. … If they want us to respond immediately, (they) should really provide the equipment to be able to achieve that.*" (ECP2)

(2) Quality and nature of information presented to the ECP

The Control Room acts as a gatekeeper for the tasks assigned to the ECPs. An issue that rises from such set up is the quality of the information relayed to the ECP. One ECP commented that the patient information from the control room (as displayed on the MIS1 screen) does not help much in assessing a patient's condition.

"*we're not really getting the appropriate information unless I then can manage to speak to the nurse who took the call.*" (ECP1)

The control room staff's situation assessment did not seem to transfer well via the electronic communication technology. In some cases, the transfer of information occurred electronically only, and not at a personal level. In these cases, very limited amount of information had been passed to the ECPs.

"*sometimes they don't ring you. They just send you a job…I've gone to job where I hadn't spoken to them at all.*" (ECP2)

A threat to Level 1 SA mentioned in Table 1 is due to the limited screen area of the Management Information System (MIS1) hardware installed in the ECP's vehicle. The incomplete information increased the time required to input the correct information into the satellite navigation system (which is separate from the MIS1).

(3) Patient-related influences

At a micro level within the system, information originating from the interaction with the patient (e.g. checking pulse pattern) affects SA as indicated in Table 1. Additionally, the patients themselves, who are viewed as the main source of information, may not be able to convey the information well.

"*Sometime (the patients) are frightened. They don't know how to explain their condition.*" (ECP2)

(4) Training and knowledge

The decision making process of the ECPs is influenced by experience and expectation. One ECP reported having more confidence in leaving the patients at home as a result of ECP training. Knowledge about local geography is also pertinent as evident in the problem regarding the incomplete postcode. The information displayed on the MIS1 screen does not lead to a satisfactory understanding (Level 2 SA) of the geographical location of the patient. The ECP who has just started working in the new area was not familiar, and had not been trained, with the street names.

"*.. you pressed that you're responding and you're moving and actually you're not because I .. don't know the area that well, and you're spending time putting it in the SatNav* [Satellite Navigation]*, which takes time*." (ECP2)

"*If you have a rough idea of an area you can be heading in the direction while the SatNav's firing itself up…rather than if you were to put me in a completely different city or area.*" (ECP1)

(5) Job design: feedback and skill variety

The example for level 3 SA in Table 1 shows how SA is related to a job design issue. The ECP reported that a feedback for a completed job would be beneficial. The feedback is important for the development of better or more accurate SA in the future.

"*[I] always try to reflect and think … was that the best plan of action or have I put them in the hospital for no real reason and …quite often there is no real feedback.*" (ECP2)

Another job design issue is skill variety. The opportunity to work on different clinical cases is regarded as valuable. Thus, the ECP did not mind being asked to perform non-ECP jobs.

"I mean my skills got better. I've been to (emergency) calls and actually been able to deal with them and involved ECP skills as well." (ECP2)

"*Because we are so specific in what we're doing, we're not really performing the full gamut of ECP tasks. Working in different clinical areas and being exposed to different clinical things on a regular basis (will) stop the skill erosion"* (ECP1)

Towards an integrated socio-technical framework for emergency pre-hospital care

This study revealed the relevance of SA as applicable in decision-making in the works of ECPs. The findings point to a range of influences spanning various levels within the sociotechnical system. An appropriate way of capturing and visualising these is to first use a framework that enables the examination of the various levels. The IDM (Wong, 2000) is a suitable model to examine some of the micro issues with a cognitive engineering orientation. Meanwhile, at the other end of the care pathway, the resilience engineering orientation, represented by the model proposed by Wears *et al.* (2008), is a suitable candidate. The two orientations are combined in an integrative manner (Figure 2) to complement each other with safety being a common thread linking them together.

Using the communication map, the Ambulance Services is divided into dispatch team and responders in the field. This distinction is meant to highlight the different nature and scale of SA and decision-making taking place in both areas. The IDM appended to the ECP is based on the IDM reported by Wong (2000). Further evidence is required to populate the modified IDM as it relates to ECPs.

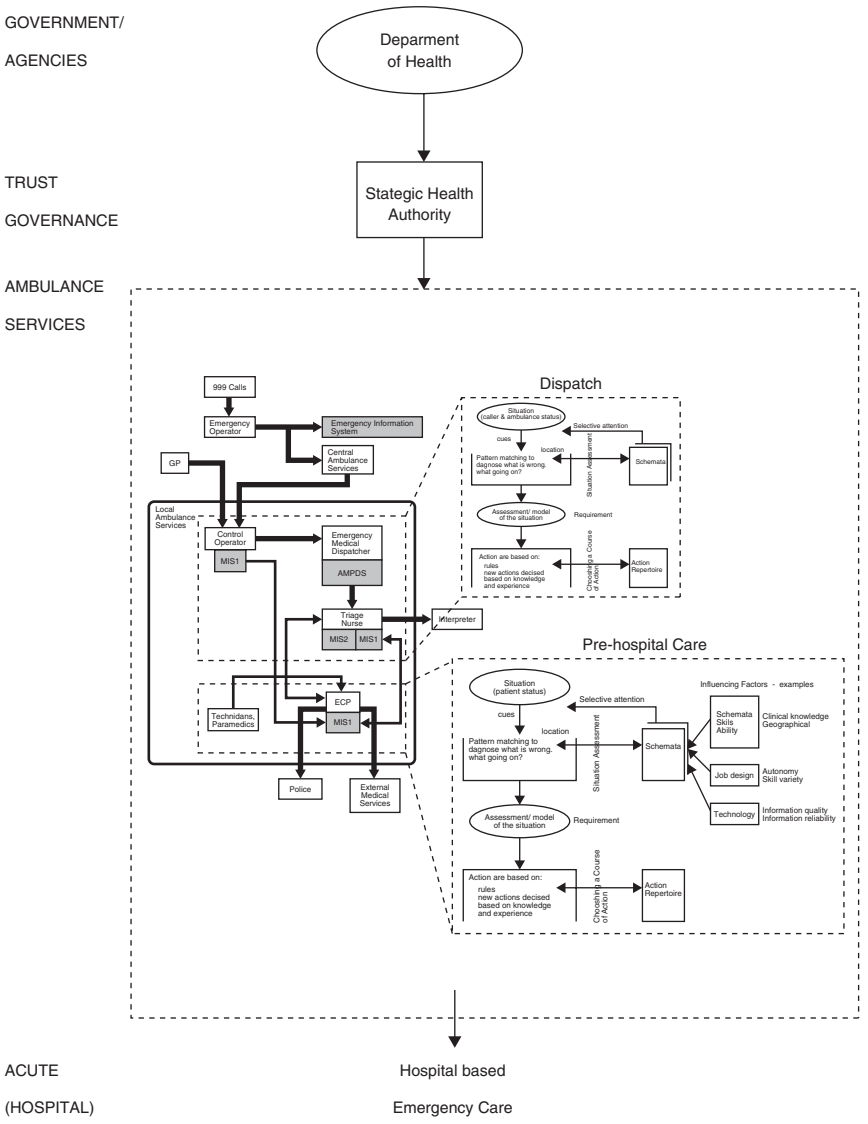

Figure 2. An integrated sociotechnical framework of SA and decision-making in emergency care.

Conclusion and implications

This paper described the development of an integrated sociotechnical system framework for SA and decision-making among ECPs. This framework will be used to investigate SA from a systems ergonomics perspective. Realising the limited number of participants in this study, this framework should be tested and validated

with a larger sample size. Nonetheless, the proposed framework can be a good starting point as it is also based on existing literature. As a research framework, it can be helpful to investigate issues in emergency pre-hospital care in a more comprehensive manner. The linkages across the system elements can be examined.

These linkages can be used to suggest job design changes. As mentioned by the participants, task variety is deemed as important. However, these aspects of the job are influenced by how the ambulance services deploy the ECPs – either mainly as solo responders treating non-life threatening cases, or as part of the pool of resources for all emergency cases. This in turn has to be aligned with the targets that the Ambulance Services has to achieve. If the existing resources are insufficient, the ECPs might be deployed to cover the shortage and meet the time-to-respond target.

For example, the framework can be tested by comparing SA and decision-making in different organisations to examine the macro level influences. A record of 999 calls received, the resources assigned, and the outcome of the patients would provide a systems perspective of the work performed by the ECPs. A part of the future work also includes getting an alternate way of validating the communication map. A different managerial staff will be approached to provide a map that will be compared against the existing one.

For the Ambulance Services, the test and validation of the framework would provide an empirical evidence for developing the ECP role. By focusing on SA and decision-making, individual factors can be identified, as well as organisational factors and job design issues. For example, the mastery of geographical knowledge can be improved to supplement the satellite navigation system. The information system devices themselves should be designed better to support the ECPs' knowledge. Thus, the ECP role can be developed in a more holistic way. Consequently, interventions for improving patient safety can also be scoped better. This would be a way for providing better emergency care in the community.

Acknowledgements

We thank the Ministry of Higher Education Malaysia, and the International Islamic University Malaysia for financial support to the first author, and Dave Whiting of East Midlands Ambulance Services for his support to this project.

References

Anders, S, Woods, D.D., Wears, R.L., Perry, S.J., and Patterson, E. 2006, Limits on adaptation: modeling resilience and brittleness in hospital emergency departments. *Paper presented at the 2nd Symposium on Resilience Engineering*, Juan-les-Pins, Paris, France, November 8–10

Blandford, A. and Wong, W. 2004, Situation awareness in emergency medical dispatch. *International Journal of Human–Computer Studies*, 61(4), 421–452

Cooper, S., Barrett, B., Black, S., Evans, C., Real, C., Williams, S., et al. 2004, The emerging role of the emergency care practitioner. *Emergency Medicine Journal*, 21(5), 614–618

Endsley, M.R. 1988, Design and evaluation for situation awareness enhancement. *Proceedings of the Human Factors Society 32nd Annual Meeting*, (Santa Monica, CA: Human Factors Society), 97–101

Endsley, M. R. and Robertson, M. M. 2000, Training for situation awareness in individuals and teams. In M. R. Endsley, & D. J. Garland (Eds.), *Situation Awareness Analysis and Measurement*, (Erlbaum, London), 349–365

Klein, G.A., Orasanu, J., Calderwood, R. and Zsambok, C.E. (Eds.). 1993, *Decision making in Action: Models and Methods,* (Ablex Publishing Corporation, Norwood, New Jersey)

Wears, R.L., Perry, S.J., Anders, S., and Woods, D.D. 2008, Resilience in the emergency department. In E. Hollnagel, C.P. Nemeth, and S. Dekker (Eds.), *Resilience Engineering Perspectives, Volume 1: Remaining Sensitive to the Possibility of Failure*, (Ashgate, Aldershot, England), 193–210

Wong, W. (2000), The Integrated Decision Model in emergency dispatch management and its implications for design. *Australian Journal of Information Systems*, 2(7), 95–107

Wong, W. and Blandford, A. 2001, *Naturalistic Decision Making in Emergency Ambulance Command and Control* (Discussion Paper Series No 2001/11, (Department of Information Science, University of Otago, Dunedin)