IMPROVING SAFETY AND EFFICIENCY WITHIN AIR AMBULANCES IN ONTARIO

Judith Seary[1,2], Vicki LeBlanc[1,3], Patricia Trbovich[2] and Anthony Easty[1,2]
1. University of Toronto, 2. Centre for Global eHealth Innovation,
3. Ornge Transport Medicine

INTRODUCTION

In 2007 Ornge Transport Medicine approached the research team at the Centre for Global eHealth Innovation to evaluate and propose improvements for the patient treatment environment of their current helicopters, as well as to develop recommendations for their future aircraft. In order to develop these recommendations an understanding of the current workflows, challenges, and requirements of the patient care area during aero medical transport is required. The following paper outlines the methods in use to achieve this objective. It is felt that this approach could be applied to investigations of other medical care environments.

The Medical Care Environment of Interest

Ornge is a non-profit organization that the province of Ontario has tasked with coordinating all aspects of Ontario's air ambulance system; it has been in operation since January 2006. It is the largest aero-medical transport program in North America with 33 aircraft across 22 bases, serving the 12.5 million residents in the province dispersed over 1,000,000 km^2 and performing over 18,000 admissions annually. Patients are transported in either a King Air 200 twin-turboprop aircraft or a Sikorsky S-76 helicopter. This investigation is being conducted on the Sikorsky S-76 helicopter.

Medical care on-board the helicopter is provided by a pair of flight paramedics with specialized training in the care of acute patients in the aero-medical transport environment. They are capable of providing hospital level complex care. The volume of the patient care compartment is $5.78m^3$ and in this limited space all the necessary equipment and supplies for providing care during flight are contained. There is also a baggage compartment that provides an additional $1.08m^3$ of storage which can be accessed when the helicopter is on the ground. Medical equipment and supplies are stored in both helicopter cabinets and in paramedic bags that are also used when treating the patient outside of the helicopter before and after flight. Only some equipment is duplicated between the paramedic bags and cabinets, thus the paramedics need to be able to access their bags while treating the patient inside the helicopter. During flight the paramedics are isolated from support facilities aside from verbal consultation with base hospital physicians.

Although this environment provides the highest level of care outside of a hospital, there is a general lack of information regarding the best arrangement and organization of the equipment within the constraints of these helicopters.

DATA COLLECTION METHODS

The human factors data collection methods being used to develop an understanding of the current workspace and patient care tasks include: shadowing, interviews, equipment inventory, and task analysis. This combination of techniques has been chosen as a way of gathering comprehensive data about the work of paramedics as they care for patients during flight. All portions of the project involving human participants were approved by the research ethics board at the University of Toronto.

Shadowing

Through the ride-out observation program operated by Ornge, the student investigator accompanies pairs of paramedics as they go about their usual work to gain a general understanding and appreciation for the work environment and the types of patient care tasks they perform. Shadowing occurs at 3 bases across the province. Each session occurs during the day and begins with the 7:00am change of shift and continues for the duration of the 12 hour shift. The paramedics begin their shifts at their base and then travel to hospitals or accident scenes to attend to patients. Most of the time is spent observing activities, but when appropriate, some questions are asked of the paramedics to ensure that their actions and thought processes have been correctly interpreted. All efforts are made to be as unobtrusive as possible; this is best for maintaining high quality of care and for observing the most natural performance of the paramedics. Occasionally, paramedics are asked to "think aloud" as they go about their work, explaining what they are doing and thinking [1]. When this

approach has been applied in other patient care environments, clinicians adopt a “teacher” role and treat the investigator as a student, which is ideal for developing an understanding of the workflow and practices [2]. Paramedics are not asked to think aloud when dealing with a medical crisis, an emergency, or when completing time-sensitive tasks.

This method of data collection enables the detailed task analysis in the current workspace. As well, this method helps identify aspects of the workspace that could be improved to better support the work of the paramedics.

Interviews

Concurrently with the shadowing, semi-structured interviews are conducted by the student investigator with stakeholders of the current air ambulance care environment to identify problems and unmet needs related to the physical layout. These stakeholders include: paramedics, education staff, engineering staff and base hospital physicians. A semi-structured approach is used because it offers the consistency of a structured interview program, but has the flexibility to probe additional areas of interest as they emerge [3]. An iterative approach to data collection is used to ensure that any relevant issues that emerge from early interviews can be explored in later interviews [4]. All interviews are audio taped to enable analysis and ensure accuracy.

This method of data collection supports the detailed task analysis. The detail provides a context in which to interpret both the task analysis descriptions and the observations made during shadowing.

Task Analysis

In consultation with the Ornge education team, detailed descriptions of how patient care tasks are ideally performed in the helicopter are being developed. Attention is paid to the sequence of actions and the items of equipment needed to complete the patient care tasks. As well, the descriptions indicate: which paramedic performs which portions of the task, where the paramedics are seated, where the paramedic bags are positioned, and where the equipment is taken from. The detailed descriptions are being developed for tasks that are known to be performed most frequently in the helicopter according to call report data. (A paramedic call report is completed for each patient that paramedics care for; along with other information, these call reports document the procedures and therapies administered.) As well, urgent tasks that are identified during interviews as being particularly challenging to perform in this workspace will be described.

This method of data collection provides a means of understanding tasks that may not have been observed during shadowing sessions or have been described in great detail during interviews. It is also a means of stereotyping tasks of interests so that a single, generalized approach for a task can be combined with other sources of information. This enables us to focus on how the workspace layout affects the task of interest, rather the variability in the execution of tasks.

Optimizing the Location of Equipment

To understand the actual placement of equipment within this workspace at different paramedic bases, an equipment inventory task was developed. Paramedics are given half an hour to individually complete the activity of indicating where in the helicopter and paramedic bags they expect to find their medical equipment. To complete the task, they are given a list of the equipment that is expected to be in the helicopter and the paramedic bags, as well as labeled diagrams of the space and paramedic bags (see Figure 1).

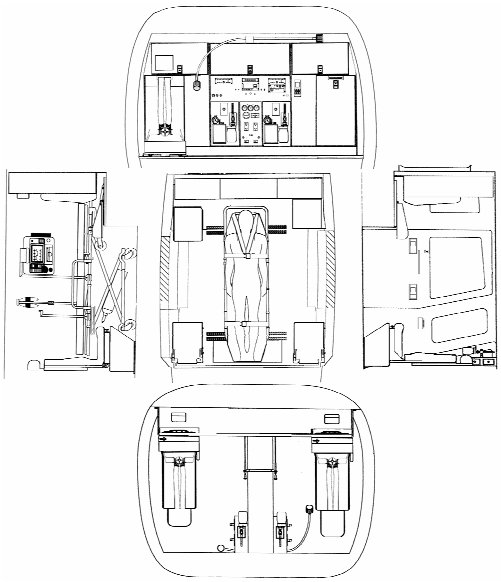

Figure 1: Layout Diagram of the Interior of the Patient Care Compartment of the Helicopter

This exercise enables comparisons among practices for the placement of equipment in the patient care compartment across the province, as well as identifies deviations from operations guidelines, and provides insight into the variance of the expected locations of equipment. Trends in the expected locations of the equipment could lead to the identification and recommendation of changes to the setup of workspace across the province. As well,

understanding the current placement of equipment provides insight into the feasibility and desirability of developing province-wide standardization of the current helicopter patient care compartment.

DATA SYNTHESIS METHODS

Two main techniques have been selected to analyze the anticipated data. Link analysis draws primarily on data from the equipment inventory and task analysis; whereas the heuristic evaluation draws on observations made by the researchers. Both techniques are helpful for identifying strengths and weaknesses of the current design of patient care workspace, which will support the redesign process.

Link Analysis

Link analysis is a technique that has been used in other studies of tasks performed in healthcare environments such as inpatient units in an acute care hospital, patient rooms in a cardiac intensive care unit and the patient care area of a land ambulance [5-7]. The technique shows physical motion between locations, as well as the frequency of motion. It can also capture communications and is adaptable for multi-person systems [8,9]. For this study, a link is defined as movements of position and attention or communication during the patient care task. This technique provides a pictorial view of how the layout of the workspace affects the performance of tasks.

The detailed descriptions of patient care tasks developed in the task analysis are used to develop a link analysis of those tasks of interest. The link analysis is mapped according to the operations guidelines and different arrangements of equipment discovered using the equipment inventory. This provides a way to compare the different arrangements of equipment. These comparisons may help identify potential benefits and challenges associated with different equipment configurations.

Heuristic Evaluation

Heuristic evaluation is a type of usability method where evaluators examine an interface (traditionally a website or software application) to identify elements that violate usability heuristics and assign a severity rating for the violation. This method has been adapted by Zhang *et al.* to evaluate medical devices and will be extended to identify usability issues for the helicopter workspace [10]. The heuristics that we anticipate being particularly relevant include: consistency and standards, visibility of system state, minimization of memory load, flexibility and efficiency, and prevention of errors.

This method is used to aid the redesign process by enabling the classification of aspects of the current patient care environment that need improvement because they violate recognized principles of good design.

CONCLUSIONS

Results of this study will be used to identify problems with the current helicopter workspace layout and to generate recommendations for improving the layout. It is expected that there will be recommendations that can be immediately implemented in the current helicopters and that there will be other recommendations that will be useful in either the development or selection of future aircrafts. From these findings, mock-ups such as a layout on paper or modified, labeled, photographs depicting the recommended modifications will be developed and presented to stakeholders (particularly paramedics) for feedback.

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