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IMPROVING RESTRAINT FEASIBILITY THROUGH AMBULANCE LAYOUT REDESIGN

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Summary: This study examined the duties performed by emergency medical service workers with the goal of increasing the time EMS workers are restrained while providing patient care during transport. An optimal layout of equipment and materials in the rear patient cabin of an ambulance was created increase seatbelt restraint feasibility for working medics. Over 13,000 EMS agency call logs were evaluated to identify medical procedures frequently performed during patient transports, which were then filmed and analyzed using Pareto and link analysis to measure restraint feasibility. An alternative ambulance layout was developed following focus group meetings, and the adjusted tasks restraint feasibilities were calculated for the alternative layout. Restraint feasibility was significantly increased for the 5th percentile female, 50th percentile male, and 95th percentile male anthropometric populations. The proposed patient compartment design increased overall restraint feasibility from 47 percent to 90 percent. The proposed design would increase safety for medics and patients during patient transports by increasing the number of tasks that could be performed from a belted and seated position.

OBJECTIVES

Ambulance-crash-related injuries to emergency medical service (EMS) workers could be greatly reduced if medics were restrained more often while riding in the patient compartment. With so many factors affecting the likelihood of an ambulance crash, there is no definitive means of reducing crash risk. This study examined the duties performed by EMS workers with the goal of increasing their restraint time. Work inefficiencies were considered to develop an improved layout for the ambulance patient compartment.

BACKGROUND

With a fatality rate of 12.7 per 100,000, EMS workers are at a high risk of serious injury on the job (CDC, 2003). EMS personnel are two-and-a-half times more likely to be involved in a crash than the general traveling public. The frequency of fatal crashes is 27 percent and 33 percent greater for ambulance workers than for police officers and firefighters, respectively (NAEMSP, 2009). The jobs of EMS workers are often performed under hazardous driving conditions and high-speed situations, requiring strict vigilance. According to the NAEMSP (2009), 74 percent of EMS worker deaths are transportation related. Transports that occur in rural areas put medics at an even greater risk due to two primary reasons: 1) road conditions in rural areas tend to be more dangerous because of narrow lanes, lack of shoulders, or poorly lit roadways, and 2) the lower density of rural populations leads to longer traveling distances. Road conditions in rural

areas add to the fact that EMS workers in the rear ambulance compartments rarely use safety restraints. Research on ambulance-crash-related injuries has shown that EMS workers riding in the patient compartment of the ambulance wear their seat belt less than 50 percent of the time (Smith, 2003). This was confirmed by surveys conducted by Gilad and Byran (2007), in which only 3 percent of EMS workers reported always wearing their seatbelt.

The lack of EMS restraint use while in the patient compartment has been attributed to the fact that “lap-belt restraint systems commonly provided in patient compartments do not allow full access to the patient” (Smith, 2003). Another factor contributing to low restraint compliance is that the seat used by paramedics is often in a poor location for providing patient care (Gilad and Byran, 2007). If the medic must access equipment on the far wall, he or she may need to lean over the patient or kneel at the side of the cot. For this reason, medics often ride unrestrained and seated at the edge of the squad bench (Smith, 2003). Other reasons for not wearing seat belts include cultural issues, social norms or personality. This low level of restraint compliance poses a great risk to the worker since risk of death or severe injury is four to six times greater for an unrestrained EMS worker than for one who is restrained (NAEMSP, 2009).

METHODS

Five years of archived patient care records were collected from American Medical Response (AMR) in Bozeman, Montana. Pareto analysis identified the EMS procedures most commonly performed while providing patient care. One professional EMS worker (EMT/Paramedic, seven years of experience) was recorded performing these procedures on a mock patient, displaying equipment locations and movements required for each procedure. The procedures were broken down into their separate movements and reach termination points. Link analysis summarized the frequency of equipment access and reaches performed by EMS workers while providing patient care. EMS worker restraint feasibility was evaluated for these activities to determine what procedures could be conducted from a seated and belted position. Focus groups were held to speak with 13 professional EMS workers about issues with equipment placement and positioning while providing patient care, then an alternative ambulance layout was developed using focus group input. The alternative layout that was developed was finally assessed for restraint feasibility using the equipment access and frequency information from the original patient care records to determine if the EMS worker restraint feasibility would improve with the new layout.

Patient Care Records

Archived patient care records (PCRs) detailing 13,252 ambulance calls between 2005 and 2010 were examined to identify EMS procedures most commonly performed while providing patient care. These records list information pertaining to the patient’s condition, treatments received, and mode of transportation (emergency, urgent, or scheduled). An emergency transport begins with a call for immediate assistance and involves the ambulance traveling with lights and sirens engaged (494 records). An urgent patient transport is a call for immediate assistance but without the lights and sirens (7,781 records). Other calls are categorized as scheduled, which can include requests arranged ahead of time for things such as transporting an elderly person to a new facility (1,672 records). Emergency and urgent patient transports are the most dangerous for an unrestrained medic riding in the rear of the ambulance and therefore those calls were the focus of

this research. In some cases, transport information was not entered in some PCR records due to a variety of circumstances (e.g., patient refused care, call was cancelled en route, or patient was treated at the scene); these records were not included in the analysis (3,306 records).

Apparatus

The vehicle that was evaluated for this project is a Type III ambulance, which is a cutaway van cab-chassis with an integrated modular ambulance body (GSA, 2007). The ambulance is a 2002 Ford E350 chassis, with a rear box manufactured by American Emergency Vehicles. A Type III was chosen as it is commonly used in rural transport settings. An overhead layout diagram and photograph of the ambulance rear compartment are shown in Figure 1.

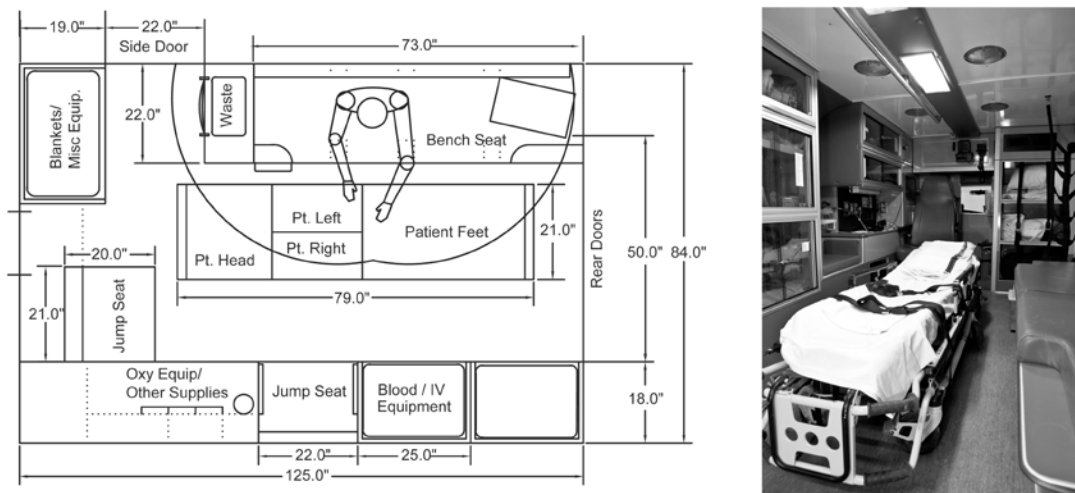


Figure 1. Diagram and photograph of Type III ambulance patient compartment

Analysis Methods

Pareto analysis was used to narrow the focus for medic activity to the most common procedures encountered while providing patient care, performed for urgent and emergency procedures separately. Of the 53 procedures listed on the patient care records, 11 were identified as those most frequently performed from the Pareto analyses. These procedures were: primary survey, secondary survey, monitor vitals, IV-peripheral, pulse oximetry, cardiac monitor, medication administration, glucometer, blood draw, 12-lead EKG, and BVM-assisted ventilation.

An EMS worker was recorded performing procedures on a mock patient in a type III ambulance to understand the specific tasks associated with the common procedures identified in the Pareto analysis, to understand the motions performed and the equipment used in patient care procedures. These videos were analyzed to collect information on each procedure relative to 1) specific equipment used, 2) actions and tasks performed, and 3) feasibility of medic restraint throughout the procedure. Only one EMS worker was used in the mock procedures as the most common layout for most EMS calls involves only one worker.

The most frequently performed activities were individually assessed to find specifically where the medic had to reach in both the ambulance cabin and on the patient to provide care. Each

activity was broken down into “tasks,” which were evaluated relative to the medic’s ability to perform the task from a seated and belted position, using reach envelopes constructed from primary medic seat locations. The reach envelopes assume a 30-degree trunk inclination to represent an appropriate forward-leaning posture observed while providing patient care (Pheasant & Haslegrave, 2006). The use of anthropometric tables for U.S. adults aged 19–65 years was the basis for the worker envelope construction, because anthropometric tables or references specific to EMS workers do not currently exist. From the U.S. adult anthropometric tables, three worker envelopes were created—one for the 95th percentile male, one for the 50th percentile male, and one for the 5th percentile female. Link analysis was conducted by examining the reaches that the EMS workers performed. Reach envelopes were used in conjunction with the task analysis and link analysis to develop an alternative equipment layout that would minimize the number of tasks an EMS worker was required to perform from an unrestrained position. The proposed layout diagrams were designed to accommodate two EMS workers, to ensure compliance with federal star-of-life ambulance design standards (GSA, 2007).

Once the alternative layout was designed, a full-scale mockup of the proposed layout was constructed at the EMS group headquarters where the EMS staff was invited to participate in a focus group. Thirteen male EMS workers participated by evaluating the strengths and weaknesses of the proposed layout. Participants signed informed consent forms in accordance with Montana State University IRB policy. Compensation of \$25 was offered for participation in each focus group. Participants received notification prior to the start of the focus group that the topic to be discussed involved alternative ambulance layouts. However, the specific layout that was assessed was not disclosed to the participants before the meeting. The focus group participants were told that the objectives of the study were to identify preferred equipment locations in the proposed layout, find improvements to the proposed layout, and to identify potential problem areas to the proposed layout. This method of conducting the focus group provided the medics the opportunity to experience the proposed layout as much as possible and therefore contribute more meaningful feedback. The session was taped and relevant comments were transcribed. EMS worker input was used to refine the alternative layout and resulted in the generation of a modified alternative layout (Figure 2). The final layout was assessed for restraint feasibility for each frequently performed procedure and compared to the original (existing) layout.

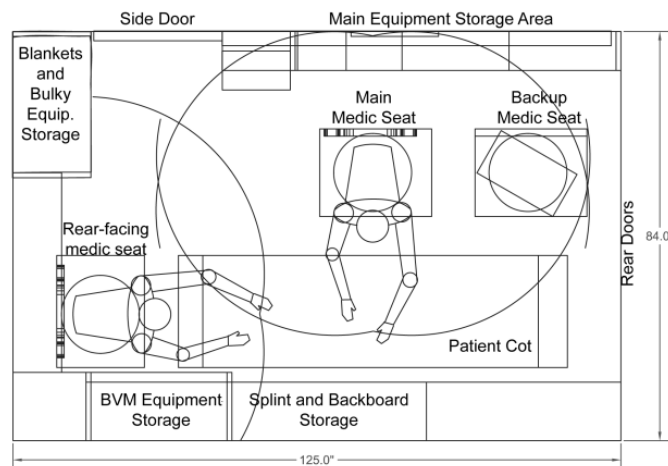


Figure 2. Proposed layout and reach envelopes for 50th percentile male

RESULTS

Assessment of equipment accessibility while restrained with the current layout design was conducted (see Figure 1 for current layout diagram). Several inefficiencies were identified in the current layout. One is that the rear-facing seat located near the patient’s head was designed to be used as the primary care location, but EMS workers revealed a clear preference to sit at the patient’s side. During the focus group discussion, EMS workers cited the desire to have social interaction and direct eye contact with the patient as a main reason for wanting to sit alongside the patient on the bench seat. The bench seat, however, is designed to be a secondary patient cot and does not offer safety or comfort for a medic during prolonged use. The rear-facing seat is used for procedures that involve assisted ventilation of the patient, as focus group members described. The current design of the rear-facing seat allows the medic to reach the patient’s head for ventilation procedures, but is not an efficient or comfortable seat for other required tasks. No matter which seat the medic is using, over 80 percent of the ambulance’s equipment is out of the reach envelope of the worker.

For the common procedures identified, each equipment and patient access region was assessed to find whether it was located within the reach envelope of the different population percentile groups (5th percentile female, 50th percentile male, and 95th percentile male). With the proposed layout, each procedure analyzed had an increase in equipment reach feasibility consistent across all population percentiles. For 8 of the 11 analyzed procedures (primary survey, monitoring of vitals, IV-peripheral, blood draw, pulse oximetry, cardiac monitor, glucometer, and 12-lead EKG), the proposed layout enabled 100 percent of needed equipment to be placed within reach of a seated, belted medic. Detailed comparisons are shown in Figure 3.

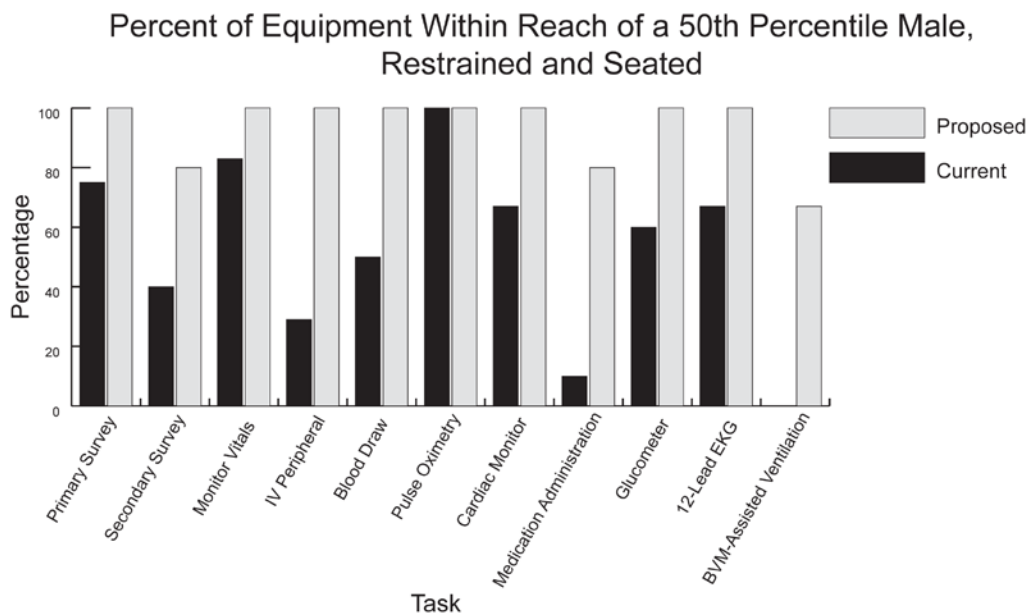


Figure 3. Restraint feasibility for frequent procedures, for current and proposed layouts

For all populations (95th percentile male, 50th percentile male, and 5th percentile female), the average restraint feasibility was increased significantly in the revised layout. A paired t-test was conducted to compare the restraint feasibility for the different tasks between the current and

proposed layout: the 5th percentile female group increased from 37 percent to 78 percent ($p < 0.001$), the 50th percentile male average restraint feasibility increased from 53 percent to 96 percent ($p < 0.001$), and the 95th percentile male average restraint feasibility increased from 53 percent to 97 percent ($p = 0.007$).

CONCLUSION

By designing an ambulance to meet the needs of the worker, restraint feasibility was significantly increased. The primary medic seat should be located to support eye contact and open communication between the medic and patient, all while remaining restrained, an aspect identified as necessary by medics. The most commonly used equipment should also be moved to be located nearer to the worker for a more efficient work flow. Since there are no standards in place for the location of equipment in the patient compartment, safety and comfort of the medic should be considered when placing equipment.

The proposed design considered both the link analysis and the identified layout inefficiencies as a basis for redesign. Restraint feasibility for the proposed layout was then assessed and compared to that of the current layout. A major component of the proposed design is the replacement of the bench seat with a swiveling chair as the main medic seat. This new chair provides greater access to the patient and equipment while restrained, as well as improved back and neck support in the event of a crash. The secondary medic seat folds down to serve as a platform for a computer monitor when it is not needed for seating, and can be unfolded and used as a second swivel seat when additional medics are present. When the backup medic seat is in use, the monitor will be stored on a bracket over the patient's legs. According to focus group discussion, this is a system commonly used in flight transports. The main medic seat and secondary medic seat swivel and fold down together to create room for a secondary patient to comply with Federal specifications (GSA, 2007; NHTSA, 1998), which state that there must be room to transport two patients in the ambulance.

With the increase of medic restraint feasibility, the redesign proposed in this study has the potential to save lives. By increasing the overall average restraint feasibility rate to nearly 90 percent, it is possible to change medics' behavior by making their work environment safer and more comfortable. It is known that fatality rates in the rear patient compartment are higher than in the front of the ambulance, especially among unrestrained workers (Becker et al., 2003). One study found that 52 percent of ambulance occupant fatalities were unrestrained occupants in the rear of the ambulance (Becker et al., 2003). While it was not clear in that study how many of the occupants were EMS care providers (as opposed to patients or companions), the ultimate goal to provide medics with a work environment where they can work from a restrained state could reduce that fatality rate. Because half (52 percent) of fatalities were found to be unrestrained ambulance occupants, the fatality rate could potentially be reduced by half from 12.7 deaths per 100,000 workers to as low as 6.3 deaths per 100,000 workers, if fatalities related to unrestrained EMS workers could be avoided.

It should be noted that an environment designed to increase safety by making it possible for the EMS workers to be restrained will still provide no safety benefit if the restraints go unused. It is important for the managing entity at a particular EMS group to encourage a safety culture and

use of seatbelts. While these types of workspace changes will increase safety for EMS workers, the ultimate success of this strategy relies on support from all elements of the EMS system. Agency managers need to enforce restraint policies, EMS workers need to support safe behaviors in themselves and their peers, and the standards system needs to support safe working conditions in terms of the actual patterns of ambulance seat use.

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