NATURALISTIC DATA COLLECTION IN RURAL EMERGENCY MEDICAL SERVICES TRANSPORTATION

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Abstract: This paper examines the behaviors of emergency medical service (EMS) workers during emergency medical transport. The study uses an advanced naturalistic data collection system to record visual, vehicle, and accessory parameters associated with each ambulance trip. Visual data was analyzed to look at restraint characteristics, position within the ambulance data, and posture data to identify areas where medics are subject to poor working conditions.

INTRODUCTION

EMS workers have dangerous jobs. A study examining occupational fatality rates on a national level found that the leading cause of occupational fatalities for EMS workers to be transportation-related incidents, at a rate of 9.6 fatalities per 100,000 EMS workers (1). This is higher than the transportation-related fatality rates for other emergency services and the general public: police show 6.1 transportation-related fatalities per 100,000 workers, firefighters show 5.7 transportation-related fatalities per 100,000 workers, and all workers in the United States showed a transportation-related fatality rate of 2.0 fatalities per 100,000 workers.

Contributing factors to these high transportation injury and fatality rates within the EMS field has not been definitively studied. One obstacle to study is the lack of central database detailing information specific to ambulance occupants or workers; the data sets that have been gathered in past studies are from several different sources—none of which parallel each other in terms of the data variables collected or data record completion.

A study on ambulance crashes in Tennessee focused on the differences between urban and rural groups (2). They found that rural areas showed significantly more crashes with injury and significantly more crashes with severe injury. Rural areas showed significantly higher rates of the ambulance being damaged, disabled, and towed, and rural areas also showed significantly more front-impact crashes than urban areas. Rural ambulances were significantly more likely to crash in areas with high posted speeds than urban ambulances.

The use of restraints is one factor in the likelihood of motor vehicle crash fatality, and is a topic which has been examined in responding EMS workers in past literature. Restraint use in the general public has generally seen to be lower in rural areas than in urban areas (3). The same difference has not been definitively studied in an emergency care environment. One study found that during emergency runs, the median restraint rate in the front cabin was 100%, and the median restraint usage rate in the patient compartment was 0% (4). The 900 prehospital emergency care providers that were surveyed submitted reasons for low usage in the rear of the ambulance – inhibited patient care (67.9%), restricted movement (34.7%), inconvenience (15.1%), and lack of effective restraints (5.3%). All of these studies were conducted by

examining police records, medic responses to surveys, or observations by a researcher riding along.

The effect of low restraint usage rates in the rear ambulance cabin on medic and patient injury in the event of a crash is compounded by the awkward postures and reaches the medics are required to perform while providing emergency medical care. Medics exhibit multiple non-neutral back postures while performing their work: twisted back postures (>20°) as well as showing a general seated posture with back flexion between 20° and 40° were observed (5).

One disadvantage of past studies is that the studied data typically involves only data associated with critical events—crashes involving injury or fatality. The data recorded on-scene is often incomplete, and difficult to find comparable data sets between different states and ambulance response agencies. Restraint usage has not been widely studied outside of crash situations, and may be a viable indicator of the safety culture of emergency response agencies. EMS worker restraint use has been studied using surveys, but has not been extensively examined simultaneously with related EMS safety behaviors and habits. The most complete data in a prehospital environment has come from direct observation; a study in northern Israel in 2007 examined physical parameters with a researcher recording activity in the rear of the vehicle from a seat in the front of the ambulance (5). However, as early as 1953, researchers have noted that directly observing human behavior affects that data. This phenomenon is widely known as the Hawthorne effect (6). A survey study in conducted with EMS groups found that prehospital care environments were not immune to the Hawthorne effect (7), so alternative data collection methods should be explored.

Studying an ambulance group in a rural emergency response environment using naturalistic data collection techniques will help to collect information on human behaviors in emergency patient care situations while minimizing the Hawthorne effect. This objective method of data collection enables natural observation of human behavior, and will help to identify areas which can be focused on in order to increase safety for emergency care providers.

METHOD

PARTICIPANTS

Project participants were emergency medical personnel working with the American Medical Response ambulance service in Bozeman, Montana. Project materials were presented to 8 medics and compensation of $50 was offered to consenting participants. 6 male and 2 female participants chose to participate. Detailed participant information is shown in Table 1.

	N	Average	SD		N	Average	SD
Gender	8	-	-	Experience (years)	8	5.2	3.35
Male	6	-	-	EMT-B	3	2.8	1.26
Female	2	-	-	EMT-P	5	6.7	3.41

Table 1. Participant Information

The emergency medical care provider, AMR, is located in an urban area in Southwest Montana. The group responds to calls involving local emergency care as well as trips involving non-emergency transports to cities in Montana. Bozeman AMR is a paid, advanced life support (ALS) emergency care provider. This facility provides care to a population of almost 100,000 people, and responds to an average of 219 calls per month. The participating medics work in twelve-hour shifts, day (8:00AM – 8:00PM) and night (8:00 PM to 8:00AM).

Institutional Review Board approval has been granted for this study.

EQUIPMENT

Ambulance

One Type III "Star of Life" ambulance was outfitted with data collection equipment, with a 2002 Ford E350 chassis, and a rear box was manufactured by American Emergency Vehicles in 2002.

Figure 1 shows the overhead view of the ambulance interior. The driver-side wall is populated with storage spaces, a convertible medic seat, oxygen supply, and electrical controls for climate control, interior lighting, and suction for a vacuum pump. The passenger-side interior contains a bench seat, restraints, and additional storage beneath the bench seat.

The rear wall of the patient compartment opens for primary patient transport entry and exit. The front wall of the patient compartment houses a rear-facing seat, additional storage, and a one-foot square window that opens for communication between the medics and the driver.

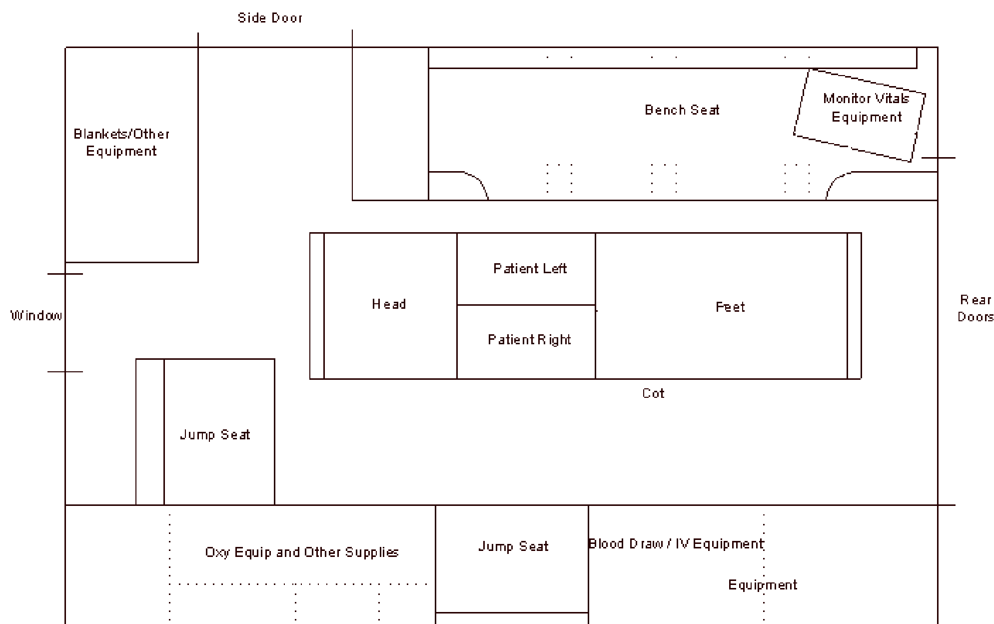

Figure 1. Overhead Ambulance View

Data Acquisition System

The data acquisition system (DAS) for this study collected visual, vehicle, and accessory hardware data during periods when the ambulance is in motion for the duration of the study. The DAS began collecting data immediately upon starting the vehicle. Data is collected until vehicle

shutdown at a rate of up to 30 Hz. Equipment installation and maintenance was performed by Transecurity. The entire study duration was three months, but only one emergency transport will be evaluated in this paper due to the ongoing nature of the data collection associated with this project.

The visual data collected was composed of two separate cameras recording events in the rear ambulance cabin. Visual data was collected at 30 Hz, and combined into a dual-pane image with H.264 video compression. The cameras were positioned so that they did not interfere with ambulance duties. The cameras are approximately 2" wide and 1.5" tall, mounted with brackets and industrial double-sided tape to ensure no damage to the ambulance box would be encountered during equipment removal. The cameras used infrared light, so they were able to capture visual data in all lighting conditions. All cables were routed under upholstered panels and concealed under cord covers to be as unobtrusive as possible.

To preserve patient confidentiality, the video image areas which most commonly feature patients were hidden with permanent static black polygon masks. The rear-facing view mask covered the patient stretcher and the entry door. The forward view mask covered the stretcher, which hid the patient on the stretcher in both elevated and prone postures.

The DAS additionally collected streaming data from the onboard vehicle computer. This data was synced with the video data. Vehicle data was collected from two areas: connections near the fuse box in the driver compartment, and connections above the rear-facing seat in the ambulance compartment. Vehicle data was used to identify vehicle motion and distance travelled.

DATA COLLECTION

The primary method of data collection involved a researcher traveling to the ambulance to retrieve hard drives filled with data collected during vehicle operation. Visually collected data was analyzed in full by a WTI graduate student researcher for the duration of the study. This visual data was evaluated to determine the behaviors displayed by EMS personnel with regards to percentage of time overall the workers interact with patients, use restraints, display different postures during transportation activities, to establish task relationships and equipment usage frequency for an ergonomic analysis of the medic cabin, and examine feasibility of medic restraint use in different postures and positions while in the medic cabin.

EMS trip data was not analyzed if at any point in the video a patient, patient companion, or non-consenting emergency care provider was observable outside of the privacy masks, to protect patient confidentiality. The data presented in this analysis is preliminary, due to the ongoing nature of the data collection associated with the project. The results shown here are relative to one rural emergency medical transport.

DATA ANALYSIS

Examination of the actual percentage of time that the medics in the patient compartment are restrained during ambulance transit used visual data taken from the two patient-compartment

cameras. These parameters were analyzed over the entire transport period, and results are reported for periods while the medic is present in the ambulance.

The frequency and length of time associated with different reaches, positions, and postures, and reaches was also examined. Interesting findings and relationships are reported.

MEDIC RESTRAINT USE

Visual data showing medic location and restraint status was analyzed to show the amount of time the medics used restraints in the rear patient compartment while in transit. The data was further reduced to examine the amount of time medics used restraints during periods involving direct patient care, as well as periods not involving patient care.

Data analyzed for this paper showed no medic using restraints in the rear ambulance cabin at any time during the study. This zero percent rate is consistent with past literature collecting self-reported information through surveys that found a very generally low restraint usage rate in the rear ambulance (4).

MEDIC POSTURES

Medic postures for the trip examined were initially differentiated between seated and standing postures. The portion of the trip with a medic visually present in the rear patient cabin was 18.73 minutes; the attending medic was seated for 15.43 minutes and standing for 3.30 minutes. A diagram showing the posture duration and sequence is shown in Figure 2. There were 9 counted periods of time involving seated postures with an average duration of 107 seconds and 9 standing periods with an average duration of 18.8 seconds.

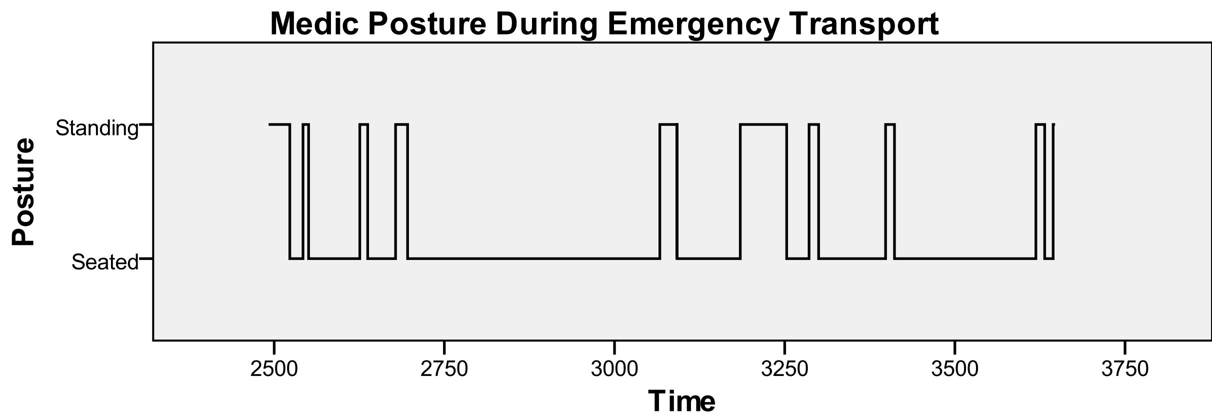

Figure 2. Medic Posture during Emergency Transport

The postures were additionally analyzed by inspecting trunk angles to identify potentially dangerous back postures exhibited by the medic during this trip. Seated and standing postures were identified as having a back posture of 0 to 20°, 20°-60°, and trunk angles of greater than 60°.

No observations showed the medic to show a neutral back posture (0 to 20°), there were 2 minutes spent with a trunk angle of 20° to 60°, and 1.2 minutes spent with the medic's body

showing a trunk angle greater than 60°. The percentage of time spent in each standing posture is shown in Figure 3.

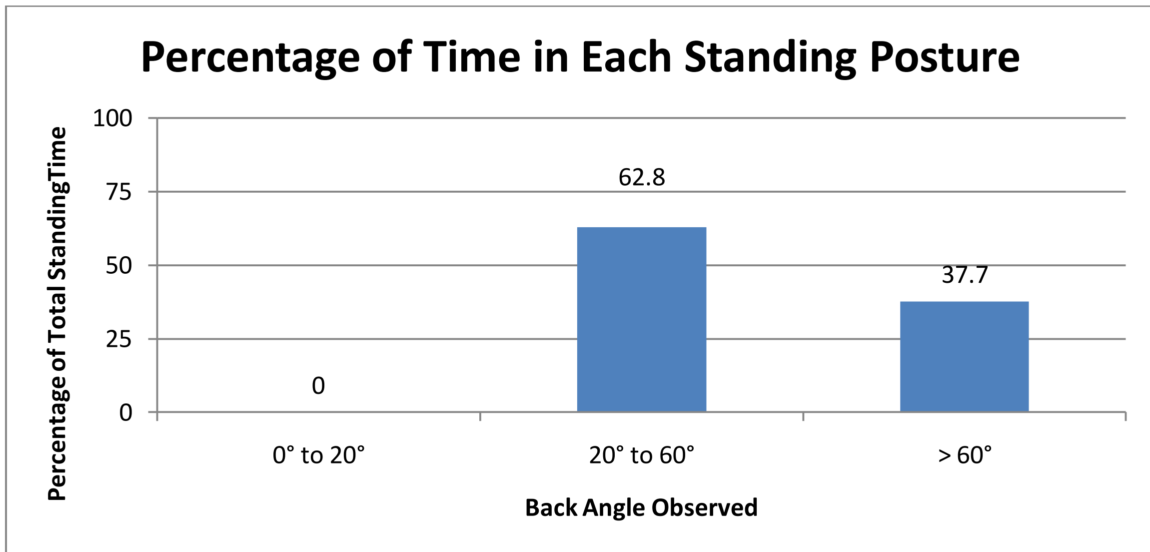

Figure 3. Standing Posture Back Angles

Similar analysis was conducted examining sitting postures, which showed that the during the 16.1 minutes that the medic showed seated postures, 14.0 minutes were in a neutral back posture (0 to 20°), 2.1 minutes showed the medic in a back posture with a trunk angle between 20° and 60°, and only 1 second with a seated back posture showing a trunk angle of greater than 60°. The percentage of time spent in each seated posture is shown in Figure 4.

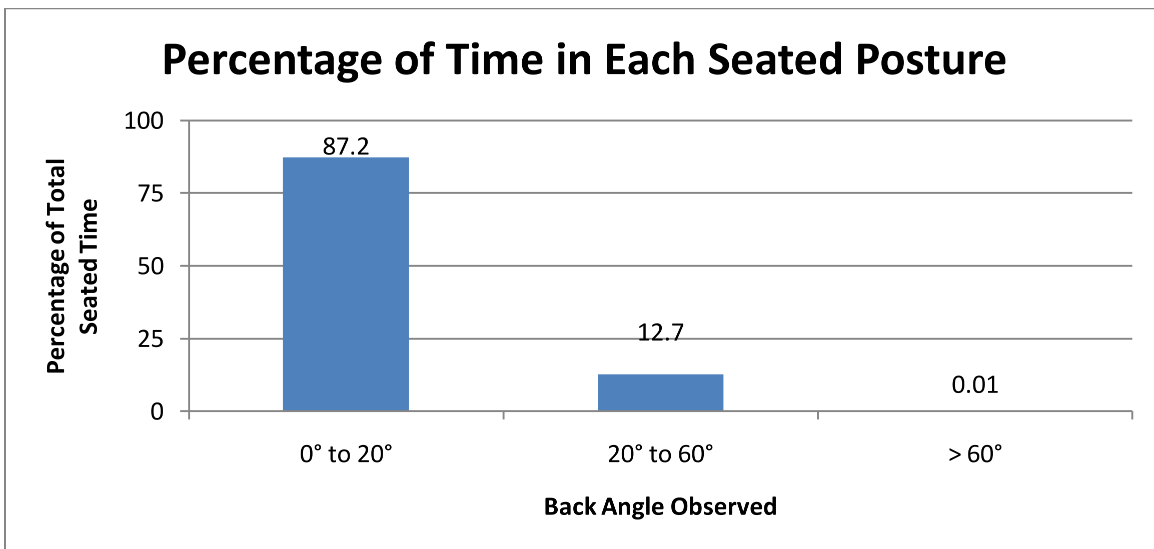

Figure 4. Seated Posture Back Angles

MEDIC POSITION

The position of the medic within the patient compartment was analyzed from the visual data. The overhead view of the ambulance was divided into four quadrants. Position 1 contains the rear-facing medic seat, oxygen equipment, and medication; position 2 contains floor space and open storage for blankets, sheets, and pillows; position 3 contains the side-facing jump seat, the majority of the patient care supplies and equipment; and position 4 contains the side-facing medic bench seat.

The amount of time spent in each position was analyzed in an effort to identify seating preference. The medic observed in this emergency transport spent 81 percent of the transport in position 4, which is the medic bench seat. The medic spent 12.6 percent of the transport in position 3. Figure 5 shows these percentages, along with how often the medic spent standing or sitting while in each position. Positions 1 and 2 showed very little activity, with position 2 occupied only while the medic was navigating around the patient on the stretcher to provide care from alternative angles.

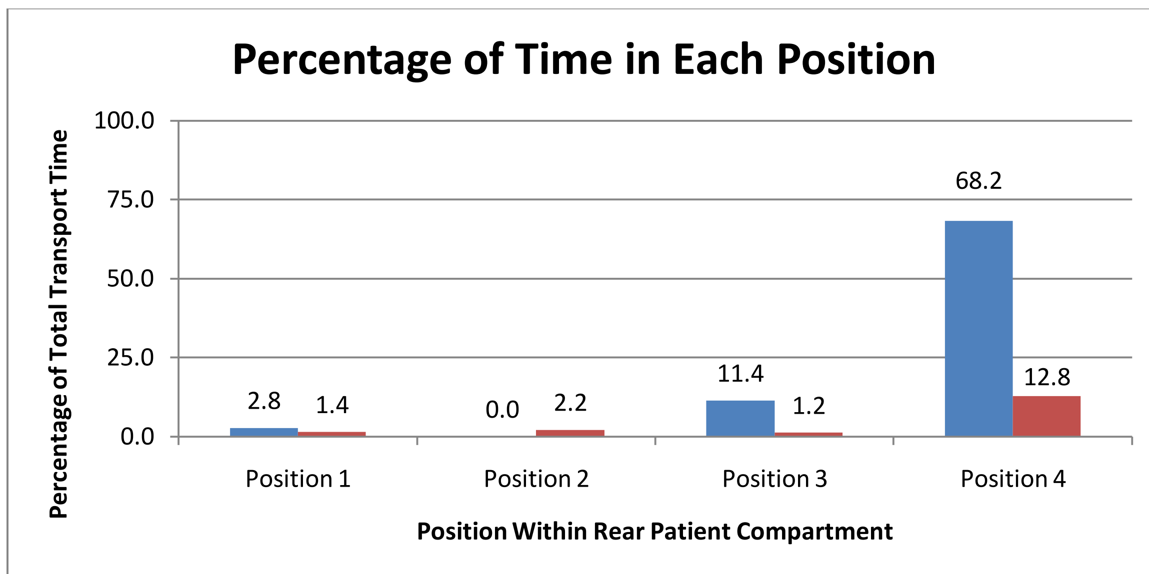

Figure 5. Medic Position within Cabin

MEDIC REACHES

Whenever the medic accessed equipment or supplies where an abrupt change in posture or position was seen in order to facilitate the retrieval or equipment access, it was documented as being a "reach."

Six reaches were observed in this transport. The reaches observed in this transport involve accessing equipment in a cabinet on the driver-side wall (2 reaches observed), adjusting the climate and light controls on the driver side wall (1 reach observed), retrieving blankets from a shelving unit on the rear-facing wall (2 reaches observed), and adjusting the oxygen controls on the driver-side portion of the patient stretcher (1 reach observed).

The only reach which was achieved from a seated posture was the medic operating the climate control panel while seated in the rear-facing jump seat. The remainder of the reaches necessitate

that the medic change from a sitting posture to a standing posture in order to complete the reach. The reaches and their observed time can be seen in Figure 6, compared with the posture patterns throughout the medical transport.

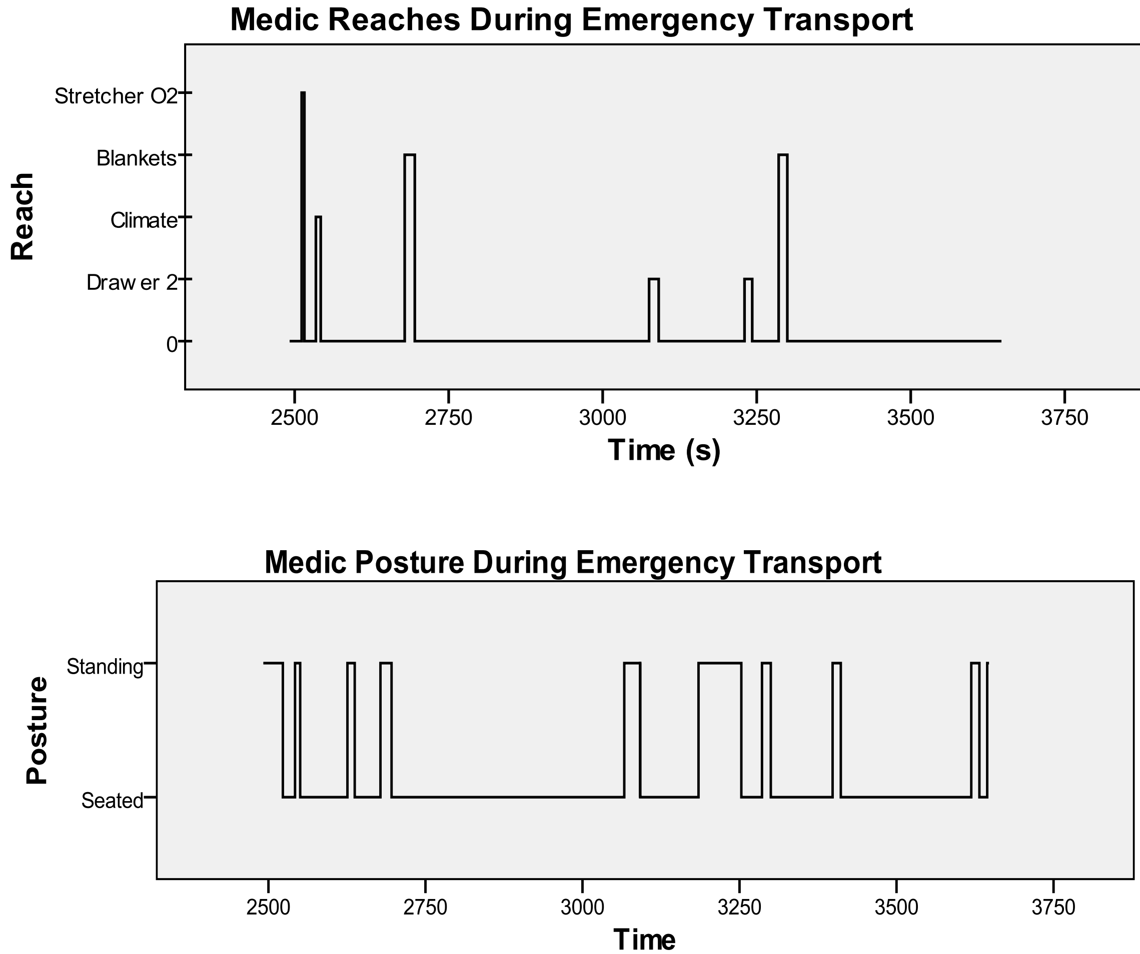

Figure 6. Medic Reaches during Emergency Transport

Every reach documented from the observed data occurs during a standing period, or immediately following a standing period. In the case of the reach for climate controls, the time immediately before and after the reach shows the medic in a standing posture; all remaining reaches show a simultaneous brief standing posture.

DISCUSSION

Rural ambulance emergency care providers are at particularly high risk of collision and injury when traveling through rural areas, yet have traditionally low restraint usage rates. The data analyzed in this study showed a restraint rate of zero percent. Reasons cited for not using restraints generally revolve around the fact that movement restriction generally inhibits adequate patient care.

The short duration of time for many of the seated postures before standing was necessary to reach equipment or provide patient care may be a factor in the generally low restraint usage rate. The case studied in this paper is representative of many of the trips where the medic is providing emergency care. The beginning of the trip shows the most frequent changes between seated and standing postures as the medic prepares the cabin for patient care work, and this often stabilizes for a length of time in a seated posture while the medic performs his work. The restraints in this ambulance are lap belts, so stationary patient care is possible while restrained. The constant need to change position and reach equipment in the rear cabin is certainly a factor in the inconvenience associated with wearing restraints while providing medical care.

Examining the specific actions within the ambulance, the majority of time spent by the medic is in seated positions with intermittent short standing periods to reach equipment, change positions within the ambulance, or reach around to treat the patient. The majority of the back angles shown in seated positions are neutral, with the more harmful postures only being shown for very short periods of time. The medic uses the side-facing bench seat the most often. If additional analysis of emergency care transports and other medics shows the same behavior, ergonomic evaluation of the ambulance and its interior will be examined keeping the primary seating location in mind.

Observations of medic standing back postures show no neutral back postures, which is not surprising, considering the cabin height. The cabin height of 64 inches does not accommodate neutral trunk postures by the medics as they maneuver through the cabin. The physical workspace provided for the medics to use while providing care during transport actually prevents safe postures and navigation throughout the patient compartment. While navigation throughout the cabin is dangerous, the organization and layout of supplies and equipment are directly contributing to increased rates of standing postures. Out of the 9 separate periods of time where the medic displays a standing posture, 7 were directly caused by the placement of supplies within the cabin and the relative position of the medic to those supplies.

The specific nature of rural crashes compared to crashes in urban environments is what makes ambulance position and postures important. A study focusing on differences between rural and urban crashes in Tennessee found that rural crashes were more likely to be front-impact crashes. The two most common positions examined in this transport both involve seating in side-facing seats--an orientation perpendicular to the direction of motion. Even with lap belts engaged, the medic still works in a high-risk environment in the event of crash or sudden vehicle deceleration. The postures and back angles the medics show while working are hazardous while stationary. In motion in a rural environment, the risk level increases.

Collecting this data through an independent system and then analyzing the video at a later date has ensured a much more thorough and accurate data reduction than the data that could be collected through direct observation. The unobtrusive nature and lack of a physically present researcher in the ambulance minimizes the Hawthorne effect, and will result in much more complete and representative data than past studies conducted with direct observation in the ambulance. This paper only represents a very small portion of the data collected for a larger project; substantially more transports and medic participation will result in stronger conclusions about medic behavior while providing patient care.

Future work will analyze specific reaches, to establish relationships between different equipment and responsive patient care processes. Reach envelopes from belted positions will be

established, along with potential rear cabin redesigns using the reach patterns established from the data collected. The ultimate goal is to help emergency medical service providers work in a safe and low-risk environment.

ACKNOWLEDGEMENTS

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