

# Improving Restraint Feasibility through Ambulance Layout Redesign

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## 1. Introduction

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 5<sup>th</sup> percentile female, 50<sup>th</sup> percentile male, and 95<sup>th</sup> 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.



Figure 1. Bozeman AMR's Type III Ambulance used for this study

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.

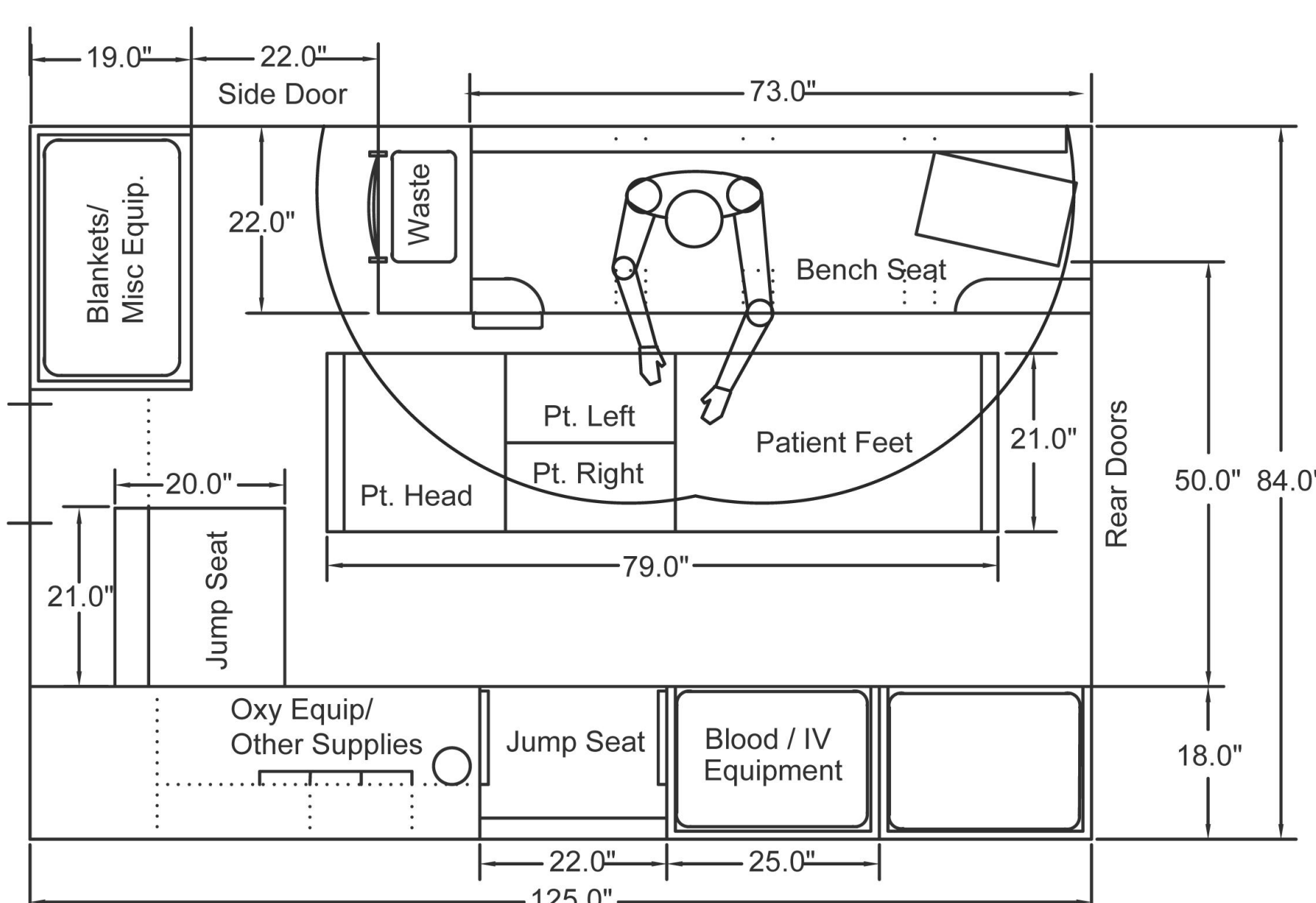


Figure 2. Overhead layout of Type III Ambulance, and photograph of the interior patient compartment

## 2. Methods

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.

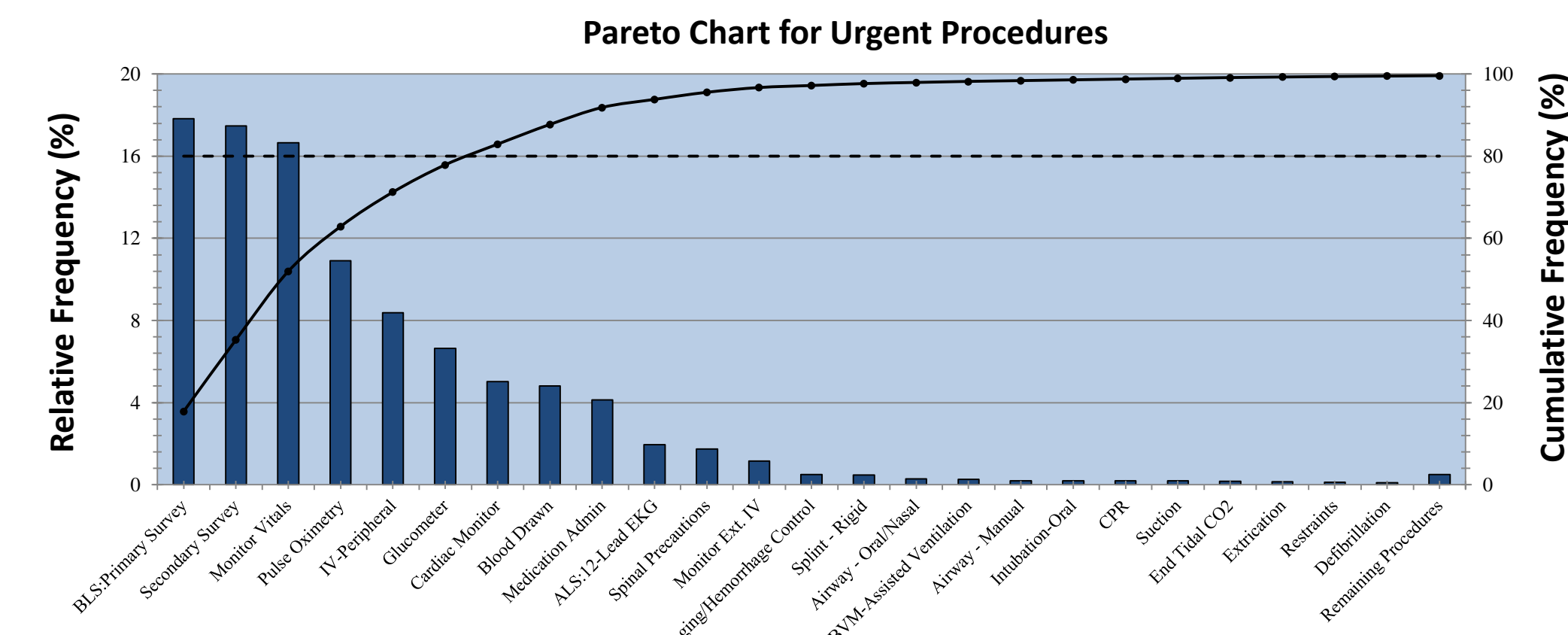


Figure 3. Pareto results for most commonly performed procedures during patient transport

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. 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.

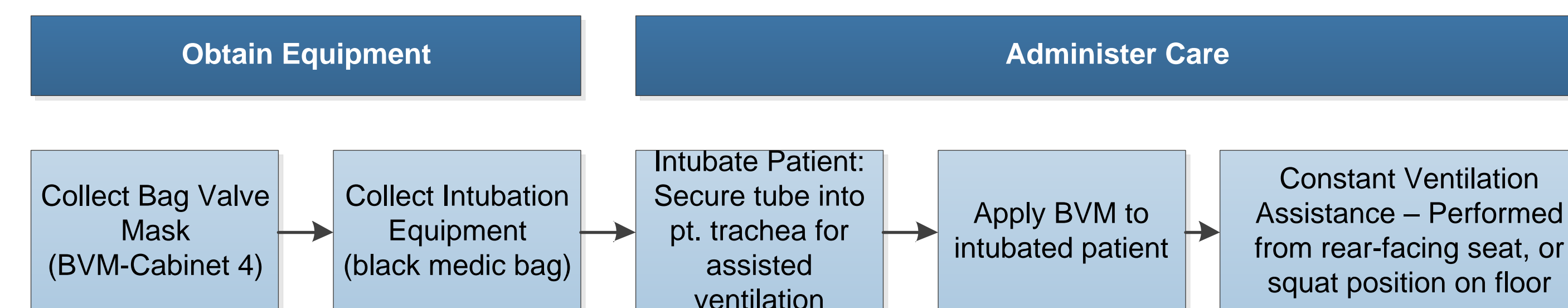


Figure 4. Example of task analysis for Bask-Valve-Mask Ventilation

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

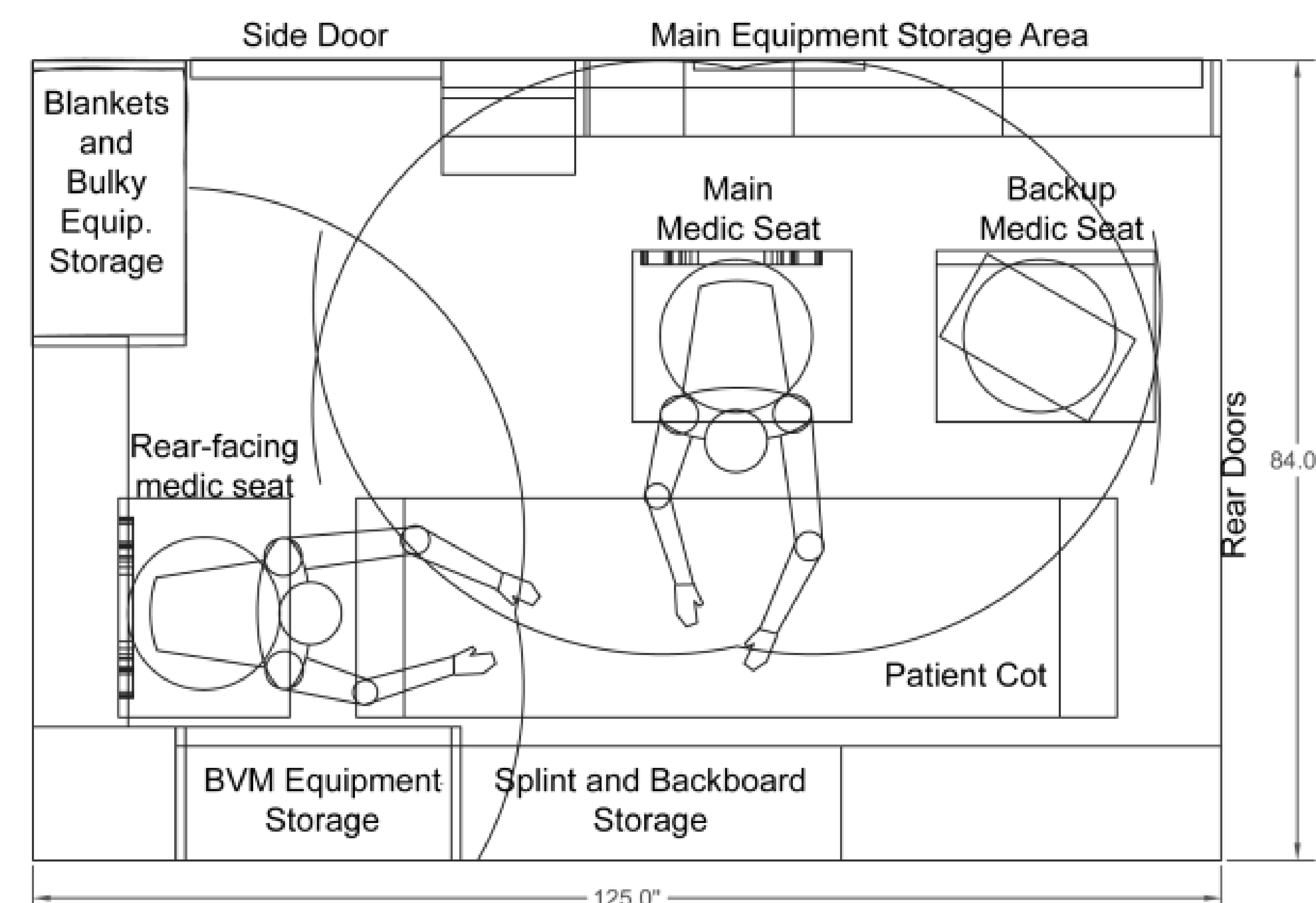


Figure 5. Revised proposed layout, with EMS worker reach envelopes (50% male)

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 5e). The final layout was assessed for restraint feasibility for each frequently performed procedure and compared to the original (existing) layout.

## 3. Results

For all populations (95<sup>th</sup> percentile male, 50<sup>th</sup> percentile male, and 5<sup>th</sup> 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 5<sup>th</sup> percentile female group increased from 37 percent to 78 percent ( $p < 0.001$ ), the 50<sup>th</sup> percentile male average restraint feasibility increased from 53 percent to 96 percent ( $p < 0.001$ ), and the 95<sup>th</sup> percentile male average restraint feasibility increased from 53 percent to 97 percent ( $p = 0.007$ ).

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.

Percent of Equipment Within Reach of a 50th Percentile Male, Restrained and Seated

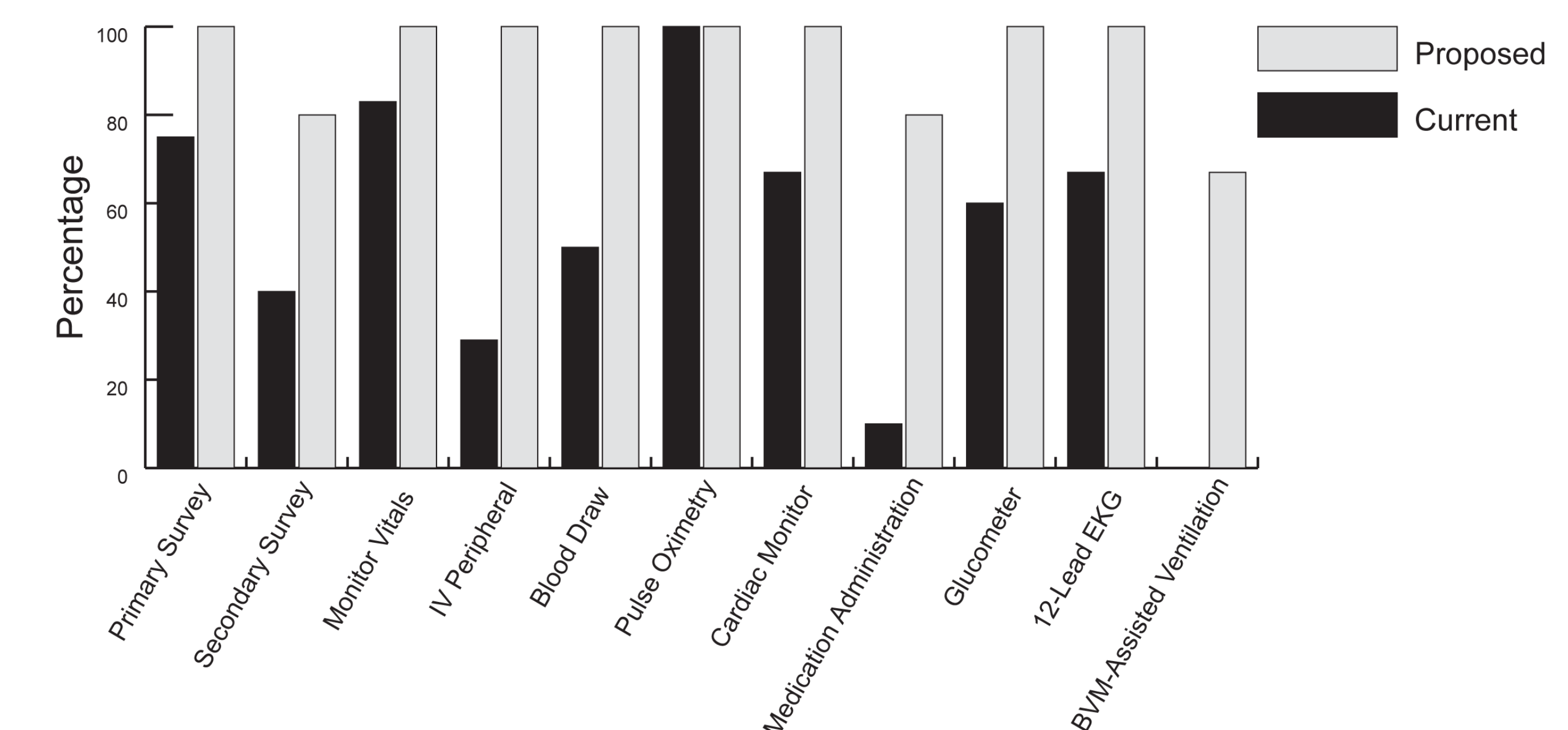


Figure 6. Comparisons for how much (%) of equipment is within reach of a medic, for the current and proposed ambulance layouts

Table 1. Changes in restraint feasibility (as a categorical variable for each task element) between layouts, by population percentile

Population Percentile	Average Restraint Feasibility for Current Layout	Average Restraint Feasibility for Proposed Layout	Change in Restraint Feasibility (percent change)	p-value
5% Female	37	78	41	<0.001*
50% Male	53	96	43	<0.001*
95% Male	53	97	44	0.007*

## 4. Conclusions

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.

## Acknowledgments

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