

USABILITY OF EMERGENCY MEDICAL DEVICES: ASSESSMENT AND DESIGN IMPLICATIONS

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The goal of this study was to assess the usability of portable electronic emergency medical equipment. The study consisted of field interviews conducted with emergency medical workers, including emergency medical technicians (EMTs), paramedics, and firefighters. We sampled a varied population, including workers from urban and suburban areas as well as private and public organizations. Equipment manufacturers can use the results of this study to enhance the usability, efficiency, and acceptability of future emergency medical devices.

INTRODUCTION

Although previous studies have investigated the clinical effectiveness of emergency medical devices, we were unable to find any studies investigating the ease of use of such devices. Further, we were unable to find any studies that addressed the needs of emergency medical workers as compared to other types of medical personnel.

Defibrillators have been investigated rather extensively in terms of effectiveness when used by firefighters versus EMTs (Weaver et al, 1988), security personnel in casinos (Valenzuela et al, 2000), on airlines (Page et al, 2000) and by paramedics in different types of communities (Stults et al, 1984 and Eisenberg et al, 1980). These studies showed the benefits of defibrillator use but did not include the emergency workers' opinions regarding the usability of defibrillators or other portable electronic devices.

Accordingly, the authors wished to investigate the needs of emergency medical personnel with the goal of developing a list of design requirements for emergency medical equipment.

METHODOLOGY

This study included a diverse sample of users, including EMTs, paramedics, and firefighters from public and private fire departments, private ambulance companies, urban cities, and suburban towns. We identified members of the target population in the Boston area by using the American Institutes for Research's proprietary database, the phone book, and Internet resources.

The geographical breakdown included four urban cities (Brookline, Quincy, and Somerville, Massachusetts and Salem, New Hampshire) and five suburban towns (Sudbury, Concord, Bedford, Wilmington, and Arlington, Massachusetts). We included five town-owned fire departments and four privately-owned ambulance companies. In total, we interviewed six firefighters and six EMTs or paramedics, numbering between one and three per company. Table 1 shows this breakdown.

We conducted the interviews at the participants' workplaces using a script that included a series of questions about: (1) general workings of the company; (2) the usage and care of their portable electronic medical equipment in general; (3) usability issues regarding the specific

Table 1: Participant Demographics by Company Type and City Size

	Fire Departments (Town-Owned)	Ambulance Companies (Privately-Owned)
Suburban Towns	Town 1: 1 interviewee	Town 4: 1 interviewee
	Town 2: 1 interviewee	Town 5: 1 interviewee
	Town 3: 2 interviewees	Town 6: 1 interviewee
Urban Cities	City 1: 1 interviewee	City 3: 3 interviewees
	City 2: 1 interviewee	

devices they used most often; and (4) suggestions for improving the usability of emergency medical equipment. For example, we included questions such as, “What device do you like using most and why?”, “What colors are most appropriate for emergency medical devices?” and “What do you worry about most when using this vital signs monitor?”

When possible, we took photographs of the electronic equipment. In two instances we rode with participants in their emergency vehicles and were able to observe the equipment in use. Photo 1 was taken during the study.



Photo 1: Emergency workers responding to a call

COMPARISONS BY COMPANY TYPE

Fire Departments vs. Ambulance Companies

Of the nine companies in the study, five were fire departments and four were ambulance companies. In terms of staff size, the ambulance companies were significantly larger, ranging from about 250 to 615 employees as compared to the fire

departments which ranged from 26 to 160 employees.

The two types of companies also differed in terms of the number of calls received each day and the times during which they were busiest. The ambulance companies received 100 to 200 calls per day while the fire departments received between 5 and 20 calls per day. There were slight differences in the “busy” time of day depending on the size of the town. Almost all companies received more calls in the daytime, with the exception of companies in cities such as Brookline, which was identified as a “bedroom” community for Boston. These communities received fewer calls during the day because residents were at work in Boston.

We also found a difference between fire departments and private ambulance companies in terms of the types of calls they received. Fire departments responded mainly to emergency calls while the bulk of calls to ambulance companies involved non-emergency patient transfers.

Finally, the most commonly used piece of equipment also differed based on the type of company. Most of the fire stations cited some type of pulse oximeter as the most commonly used piece of equipment with the defibrillator second. In contrast, almost all of the ambulance companies cited a combined vital signs monitor/defibrillator as the most commonly used piece of equipment.

Urban vs. Suburban Population Served

The data showed that both urban fire stations and ambulance companies employed more personnel than their suburban counterparts. The

urban stations also received more calls daily than the suburban companies.

Almost all companies reported more calls during the daytime for a variety of reasons. Many cited the elderly population as a reason for increased daytime calls. For example, as residents begin to wake up, the personnel in nursing homes and assisted care facilities find patients who have had some kind of trouble during the night. Thus, the personnel begin to call ambulance services. In another example, some towns experienced increased calls during the day due to the number of companies employing workers in the town. For “bedroom” communities, however, the opposite was true, as explained earlier.

All companies in the study showed similarities in the types of calls received, with cardiac or respiratory problems occurring most often, commonly dealing with the elderly. The second most common type of call was reported to be motor vehicle accidents.

USERS' ASSESSMENT OF ELECTRONIC MEDICAL EQUIPMENT

This section presents users' responses to questions regarding the use of portable electronic equipment. Here we identify trends in the ways workers use the equipment and what they consider to be positive and negative features.

Positive Features

Participants identified a number of positive features and beneficial design aspects of commonly used equipment. Equipment specifically cited for positive features included the Laerdal Automatic External Defibrillator, the Nonin Pulse Oximeter, the Medtronic Lifepak 5000 and Lifepak 12 and the Zoll vital signs monitor. Some of the features making these products superior included, in order of importance:

- convenient size, shape, and light weight for carrying easily,
- high reliability,

- quick results with no need for warm-up or calibration,
- high visibility of digital displays, and
- ability to easily use the device simultaneously with other pieces of equipment.

Usability Issues

When asked about general usability issues with electronic equipment, participants mentioned the following:

- large, heavy, cumbersome devices that are difficult to carry,
- devices that give unreliable or inaccurate readings,
- devices that require frequent calibration and/or are slow to give readings,
- designs that do not accommodate the extreme environments encountered in the field,
- short battery life,
- cords that become tangled with cords from other devices,
- products with small parts that become lost, and
- electronic displays that are unreadable in bright- or low-light situations.

During his interview, one paramedic explained, “Basically, if the device is hard to use, the guys will find a way around it. Likewise, if it proves to be inaccurate, even just a few times, it will quickly gain a reputation as a ‘useless piece of junk’ department-wide.”

Products that participants mentioned as having usability problems included suction units, which are difficult to clean, and older defibrillators that are much heavier than today's devices and do not include the simple and effective auditory and visual feedback found in today's devices.

Equipment Abuse

Emergency medical devices undergo a great deal of abuse, creating a significant need for protective features. Some of the common forms of

abuse are throwing equipment to another EMT and dropping or kicking equipment accidentally while on the scene. Additionally, equipment gets bounced around on the trucks while in transit. Devices that are attached to the wall for charging while not in use may be forcefully pulled out of their storage spaces, thus ripping the cords out of their sockets.

In all of the interviews, carrying cases were identified as essential to device success. Helpful accessories included:

- shoulder straps with connecting swivels (clips that attach the strap to the bag),
- zippers with protective guards that prevent the fabric of the bag or pieces of the equipment from getting caught in the zipper, and
- protective features to prevent damage from dropping, kicking, and other forces.

Environmental Factors

The environments in which emergency medical equipment is used can also create problems. For example, equipment may be exposed to rain, mud, snow, and temperature extremes (on the vehicle and while in use). Devices are also used in the dark by the side of highways at night, as well as in smoky apartment buildings and warehouses. The ability to clean the equipment is very important, as is designing the equipment to withstand these harsh conditions.

Display Screens

Interviewees mentioned that viewing angles and brightness affect display legibility. Almost all participants described difficulty reading displays in sunlight. In order to combat these problems, high-contrast displays (such as amber or green on black) are very important. Users considered LCD displays to be better for sunlight situations, but LED displays to be better for nighttime situations. Participants preferred tilted screens to ones lying flat because they provide a wider viewing angle. In one instance, a paramedic stated that his company selected a vital signs monitor over its competitor specifically because it had a tilting display. Photo 2 shows a tilted display on a portable monitor.



Photo 2: A tilted display screen

Another important aspect of the display screen is its color. Participants varied in their preferences for monochrome versus color displays. Those who preferred color said it could be useful to highlight critical parameters. Other users found red to be a problem in sunlight conditions. The general feeling, however, was that the specific color is not so important as long as the screen is easy to read.

Equipment Labeling

We found that every company labeled each piece of portable equipment to prevent it from becoming lost. Because of the high levels of stress and energy at an emergency scene, devices that are taken off the truck but not used can be left behind. Interviewees used a variety of marking techniques, including stickers, etching, or permanent marker. A label on a piece of equipment usually included the name and phone number of the company.

Since some pieces of equipment are extremely expensive, a few companies went so far as to mark every part of the device so a part could be returned if lost. Photo 3 shows equipment boxes labeled in permanent marker.

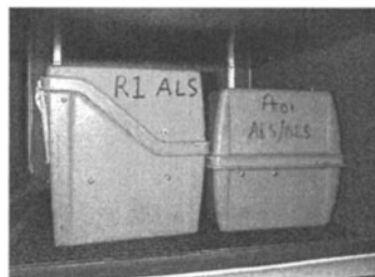


Photo 3: Equipment boxes labeled in permanent marker

Appearance

Participants considered the appearance of the devices to be very important. They were divided, however, over the conflicting needs for visibility and the appearance of cleanliness. Some participants preferred bright colors that are easy to see in the dark and easy for bystanders to spot if the equipment is lying on the road. Some companies went so far as to apply “Scotch Light” or other glow-in-the-dark/reflective materials to their equipment in order to make it more visible.

While acknowledging that bright colors are important for identification, other companies preferred dark colors because they hide dirt and grime. Participants pointed out the difficulty in keeping brightly-colored equipment cases looking fresh and new as dust and dirt build up on them and become imbedded in their fabric. They stated that dirty-looking cases give patients a negative impression of the company. One participant suggested standardizing colors for different types of devices in order to help users know which device to grab when in a hurry.

Photo 4 shows a brightly-colored case and Photo 5 shows a black carrying case with reflective labels, which may provide the best compromise in terms of visibility and appearance.



Photo 4: A bright yellow carrying case



Photo 5: A black carrying case with reflective labels

SUMMARY

This study was valuable in identifying both positive and negative aspects of emergency medical equipment. Manufacturers of emergency medical devices would benefit from considering these aspects when designing future equipment. Additionally, it is critical that these manufacturers conduct evaluations with users in the field during the design process.

Future human factors studies of emergency medical equipment are also warranted. For example, product manufacturers may find it valuable to conduct usability tests that compare two devices offering the same functionality. It may also be valuable to conduct time and motion studies of emergency medical equipment as it is used in the field to identify ways in which products could be made more usable and efficient.

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