

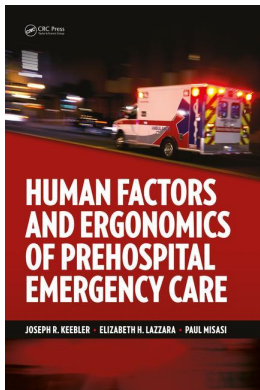
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## **Human Factors and Ergonomics of Prehospital Emergency Care**

### **Critical Essays in Human Geography**

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### **Changes from Within**

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# 12 Changes from Within

## *How Paramedic Services Can Lead the Way Human Factors Are Implemented in Healthcare*

*Yuval Bitan*

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Healthcare working environments and procedures can be improved using human factors methods and tools, but because healthcare is a complex system, it is difficult to implement and evaluate modifications in this environment. If we could test the effects of these modifications in a controlled environment, it would be easier to then implement them on a larger scale in healthcare. The distinct characteristics of paramedic services make them a unique healthcare working environment, which is ideal for implementing and testing such modifications. Paramedic services can, thus, become a good test bed for modifications in a healthcare environment. This chapter

will discuss the unique characteristics of paramedic services, describe some of the quality improvement work that was done in paramedic services, and examine what it takes for the paramedic services to lead human factors research and implementation.

## INTRODUCTION

This was just another routine call. The pager reported that the patient slipped and fell in his driveway while taking out the garbage. He suffered pain and could not move his leg. It was a dark night and the two paramedics who arrived at the scene crouched around the patient and evaluated his condition. He had severe pain so they started the pain protocol—one dosage of Morphine. One paramedic took a Morphine vial from the medication case and verified that it was the correct vial. Although he was the one who restocked the medication case at the beginning of this shift, and he remembered inserting the Morphine vial into the empty “pocket” in the medication case, he automatically took a look at the label to verify that it was in fact Morphine before opening the vial. His medic partner prepared the IV line while he drew the medication from the vial and got ready to give it to the patient. Soon they will take the patient into the ambulance, he will jump into the driver seat, and they will be on their short way to the hospital. Only at the end of the shift when he and his partner were cleaning the back of the ambulance and restocking the medication case, he saw that one Midazolam vial was missing, while all the Morphine vials were still there. “Which patient got the Midazolam?” he thought to himself. He could not recall any patient that required Midazolam during that shift. Only then did he start to think about the “strange” reaction of the patient with the broken leg to the Morphine. “He was not responding as I would expect from a 40-year-old patient. He shouldn’t have knocked unconscious from this dosage.” Something went wrong, very wrong. Now the questions started bothering both the paramedics and the patient’s family—how could this happen? How could an experienced paramedic like him deliver a dosage of the wrong medication to the patient? There was no “special” pressure during this call, just another routine call, and still such an awful error happened.

Figure 12.1 shows a medication case that paramedics use in some services.



**FIGURE 12.1** Medication case.

James Reason (2013) explains that there are many ways in which things can go wrong in any routine process. In this chapter, we will focus on how using human factors tools and methods to implement improvements in healthcare can reduce the chances for such events and how the experience gained from these improvements can serve not only paramedic services but also the entire healthcare system.

## HEALTHCARE IS A COMPLEX SYSTEM

The healthcare working environment is known to be dynamic and hectic (Cook and Woods, 1994). It has been compared to complex working environments such as aviation, but there are some characteristics that make the healthcare environment unique even among complex working environments. There are a number of contributors to this complex working environment. In addition, scientific development and new technologies change healthcare in a pace that seems to be accelerating over the years. Understanding the unique characteristics of healthcare is the first step toward developing an approach that may actually generate improvement in this environment.

We should start with the obvious—clinicians need to perform demanding and complicated tasks, some of them life threatening to the patient, under constraints of time and physical location. The need to perform some of these tasks out of the regular working hours is another contributor to the challenge that clinicians face during their work.

Another type of complication is related to the equipment that clinicians use. In most cases, this is unique equipment that was designed and built specifically for clinical care. These technical solutions require the clinicians' technical skills and training. But the lack of standards for the design of many features in medical devices makes their usage challenging and a source of use errors. Another challenge associated with the usage of the equipment is the fact that most healthcare workstations are composed of a collection of devices and instruments which were set ad hoc around the patient bed. This makes each patient room a unique working environment, which clinicians have to familiarize themselves with before starting to work.

Communication gaps between team members with varied clinical backgrounds and experiences are also a source of complexity in healthcare. Among the clinicians who work around the patient bed, the only consistent characteristic is that most of these clinicians will be replaced by their colleagues at shift change, two or three times a day, every day.

However, the main factor contributing to the complexity of this working environment is the conundrum of the human body. The subject of the clinical treatment is a unique organism of which the behavior and responses to interventions are not completely predictable neither by technology nor by experienced professionals. This phenomenon requires the system designers to leave plenty of room for variability and flexibility in any aspect of the healthcare system operation.

## IMPROVEMENTS NEED TO HAPPEN

The first signals that patient safety in this complex system might be in danger were identified in the early 1980s (Schreiber et al., 2016) but did not immediately generate

much discussion nor action. Clinicians and researchers from within healthcare organizations started to realize that something needs to change, but the early patient safety movement had a slow uptake. Early studies imprinted the areas of research that helped highlight the uniqueness of the healthcare working environment as a complex system that needs to use tools and methods that are similar to those of other high-risk industries. Only in 2000, a series of reports and studies (e.g., Kohn et al.'s [2000] report *To Err Is Human*) alerted the public to the notion that the healthcare complex system is prone to adverse events and these are occurring at an alarming rate. However, this exposure mainly pushed toward the developments of law practice and risk management departments. Only in recent years, we see the evolving of a better understanding of the notion that only design changes that will make the devices, the processes, and the working environment better fit to the user will result in system resilience (e.g., Reason and Reason, 1997). In the last decade, there has been an increase in the research and in the number of consultants working in this area, and more quality improvement projects within the hospitals are focusing on improving patient safety.

## WHY IS CHANGE SO SLOW?

One of the characteristics of a complex system is that it is difficult to implement changes. Complex systems are composed of many subsystems with complicated connections and relationships, so it takes a long time until a change in one part affects other parts. In addition, when implementing changes, there is a need for a lot of coordination among the subsystems in order to get the desired result.

Many people believe that implementation of technology and automation processes would improve the healthcare system, but case studies (e.g., Cook and O'Connor, 2005) from many such implementations demonstrate the challenge. Any change in one subsystem affects other subsystems, generating a reaction chain of which the effect on all subsystems is not always predictable. These changes might require new communication and information-sharing channels, customized training for all the staff through their professional groups, and plans for careful transition phase.

Another obstacle for introducing changes is the difficulty in collecting data that will clarify the need for change. There are several factors contributing to this challenge. First, it is not always clear what the goal of the change is. For example, are we trying to improve efficiency or patient outcomes? These are not necessarily “in conflict” but demonstrate the need for clear definition, including the parameters that will measure this modification. Another challenge is that collecting data in the field is a very noisy and imprecise process that introduces a lot of “noise” and variability, which makes it more difficult to draw conclusions.

Lastly, as demonstrated in many reporting system projects initiated by healthcare organizations, healthcare employees have very low incentive to report incidents. The reasons for this are varied, and we will refer here to only two of them. The first reason is the policy to blame and punish (e.g., Leape, 2009) the clinicians at the “sharp end” (nurses and physicians). The second reason is that in healthcare, it is sometimes hard to notice when an adverse event happens, and these incidents are discovered

only in retrospect, as what happened in the sample case at the beginning of this chapter. This results in reporting only incidents that are visible (i.e., must be reported) but neglecting all the small incidents that could teach the system a lot (Hollnagel, 2014) but never get to the sunlight.

## PARAMEDIC SERVICES: MISSION AND CHALLENGES

Paramedic services (also known as EMS, paramedicine, or prehospital care) are a critical component of public safety and central to the functioning of the healthcare system. Paramedicine usually involves emergencies with very sick patients who need immediate medical attention. Paramedics are often the first point of clinical contact for patients in these critical situations. The challenge faced by paramedics while diagnosing the patients' condition with minimal tools and technology is complicated by the fact that their work is done in places which are not designed for healthcare procedures such as the side of the road. No lab tests or advanced imaging can aid them in diagnosing the patients that, in many cases, are in extreme need for help.

This complex working environment is often fast paced, physically dangerous for staff, and of high stress and requires quick decision-making and action. Interventions performed by paramedics often involve procedures that, if performed incorrectly or at the wrong time, can cause serious harm to patients. In this high-risk environment system, failure can happen, and adverse events occur. Safety incidents such as failure to follow treatment protocol, medication errors, and failed communication have been documented in the literature (Vilke et al., 2007).

Although paramedic services are a critical part in health treatment, it is often a neglected component of the healthcare systems. Historically, paramedic services were affiliated with public safety rather than healthcare. Many services still follow the strict rules of uniforms and ranks that highlight hierarchy in other public safety organizations such as police and firefighters. On the other hand, the field of paramedicine, which is relatively new as a separate discipline, still bases many of its operations on practices inherited from hospital settings, which include the use of devices, procedures, and settings that are similar to the ones used in EDs and intensive care units. Unfortunately, those practices are often inadequate for the unique environment in which paramedics work, with consequences that can ultimately affect the health and safety of both paramedics and their patients.

One problem with paramedic services is the small number of studies that were done on paramedics' work. While other healthcare environments follow the established practice of evidence-based medicine, not many studies have targeted this environment, and the ones that did focused mainly on occupational injuries (e.g., Letendre and Robinson, 2000) and operational aspects (e.g., Giang et al., 2014) rather than clinical and safety issues (e.g., Bigham et al., 2011). One reason for the scarcity of studies might be the fact that the paramedics' working environment is very limited and packed, and it is difficult to conduct research in such an environment (you can find more on the uniqueness of the paramedics' working environment later in this chapter).

## UNIQUE CHARACTERISTICS OF PARAMEDIC SERVICES FOR IMPLEMENTING CHANGE

Paramedic services have several unique characteristics that make these organizations better fit for implementing human factors improvements.

### SMALL ORGANIZATIONS

Paramedic services tend to be small compared to other healthcare organizations. For example, a city such as Toronto (Canada), with a service area of 650 km<sup>2</sup> and a daytime population of 3.5 million people, is served by one EMS organization, Toronto Paramedic Services, that employs around 1000 employees. For comparison, the number of hospitals operating in the same city is more than 40, with just one of the hospital networks (University Health Network) that includes 6 hospitals (total of 1200 beds) and has 8000 full-time employees.

### FEW PROFESSIONAL GROUPS WITHIN THE ORGANIZATION

As the work in healthcare became more complicated and advanced over the years, healthcare professions became more specialized. These days, healthcare clinicians around the patient bed have many specific proficiencies and specialties. In contrast, the roles of paramedic services have not evolved into many specialized professions and paramedicine was developed into two main levels of expertise—Primary Care Paramedics (also known as EMTs) and Advanced Care Paramedics. In addition, in some jurisdictions, there are also first responders who are part of the paramedic services but have less training and professional experience and intensive care paramedics who handle transport of complicated patients. Still, the majority of the service is provided by just the first two professional groups. This rather simple structure is a major advantage for ease of communication between team members, because they all speak the same “language” and use the same terminology. It is also an advantage for training and developing teamwork.

### WORK IN SMALL TEAMS

Paramedics usually work in small teams of two paramedics. In most of these teams, one of the paramedics is at the level of Advanced Care Paramedic, while the other is less senior. This “grouping” dictates how the team splits the work between the two paramedics—based on their accreditations.

Paramedics have limited channels to consult with other clinicians about the clinical treatment that they should provide during the call, and they can rely mainly on their own and their partner’s experience. Taking into consideration the importance of collaboration within the paramedic teams while providing care to patients, it is not surprising that although they are not bound to work with the same partner, many paramedics prefer it (e.g., Patterson, 2011) because they find it easier and more efficient.

This type of team is unique to paramedic services since it is very small and the training of both team members is very similar (both Primary Care Paramedics and Advanced Care Paramedics share the same basic training). It guarantees that the communication challenges will be minimal.

### **LIMITED EQUIPMENT INVENTORY AND WORKING ENVIRONMENTS**

The number of equipment items that paramedics use is relatively small. For example, the Ontario Paramedic Services' (Canada) list of equipment for ambulances contains only 115 items, including nonclinical items such as light sticks and towels. An Advanced Life Support ambulance will add 55 items (Provincial Equipment Standards for Ontario Ambulance Services, November 2013). This makes the process of updating and changing the equipment that paramedics use a doable task, if necessary.

Since scenes where paramedics find their patients might be uncomfortable and inappropriate to work, paramedics prefer to take care of their patients in the ambulance. This compact working environment has many limitations, and the access to the patient may be restricted, but it provides a clean and steady work surfaces and good lighting. In contrast to the ambulance, working in the field is known to be challenging not only because of the physical constraints but also due to interruptions from family members and bystanders. This leaves paramedics with just two limited working environments that need to be designed—the paramedics' response bags (also known as jump bags) and the ambulance interior design. Changes in these environments can be done at the level of local services and do not require a big budget for planning and implementing the change.

### **CLEAR HIERARCHY**

As an organization that originated from the public safety service, most paramedic services have a very clear hierarchy and one chain of command. All organizational and clinical decisions are taken under this chain of command, and all members in the organization know their position on this chain. This makes the process of implementing organizational changes much easier than in other healthcare organizations.

### **SHORT CLINICAL PROTOCOLS**

Paramedics' clinical treatment protocols are very clear and relatively short. While the paramedics' main challenge is to identify the most critical clinical conditions that require immediate intervention, once they decide on the clinical protocol, they have to follow that there are not many additional clinical decisions that they should take. Most of the clinical work is technical and based on the detailed protocols that they are well trained to perform. These short protocols allow simple implementation of modifications and improvements within the clinical protocols.



### **FREQUENT TRAINING SESSIONS**

Paramedic services maintain the clinical education of their paramedics through annual training and certification process. Since the equipment that paramedics use is relatively simple, training facilities are within reach for all services and this allows frequent training to all paramedics in the service. While not all countries require paramedics to maintain their certification through annual exams, it is common that all paramedics in the service will go through some kind of training at least once a year.

The mentioned characteristics make paramedic services a domain that can implement change and experiment with new methods that would be more difficult to try in other healthcare domains. This is also a domain that enables easy access to data and simple data collection processes compared to other parts of the healthcare system. We may therefore use paramedic services as a test bed for implementing changes which may inform their application to the rest of the healthcare community.

### **HUMAN FACTORS PROJECTS IN PARAMEDIC SERVICES**

Human factors, which is the study and design of systems, devices, tools, procedures, and processes to better fit users' physical and cognitive abilities, is taking a major part in system improvement. Human factors data collection methods such as observations, interviews, focus groups, and surveys are important for collecting data about the users and their working environment. Tools such as task analysis, heuristics, usability testing, and simulations are used for formative and summative evaluation through the development phase and before and after a change in the current system is designed and implemented. Organizations also use human factors experts to lead processes such as failure mode and effect analysis, root cause analysis, user-centered design, human factors-informed procurement and implementation, and improving teamwork and safety culture evaluation. Following several decades in which human factors took major part in improving safety in other domains, such as aviation, the methods and tools of the human factors have recently begun to change processes, procedures, and working environments in healthcare as well.

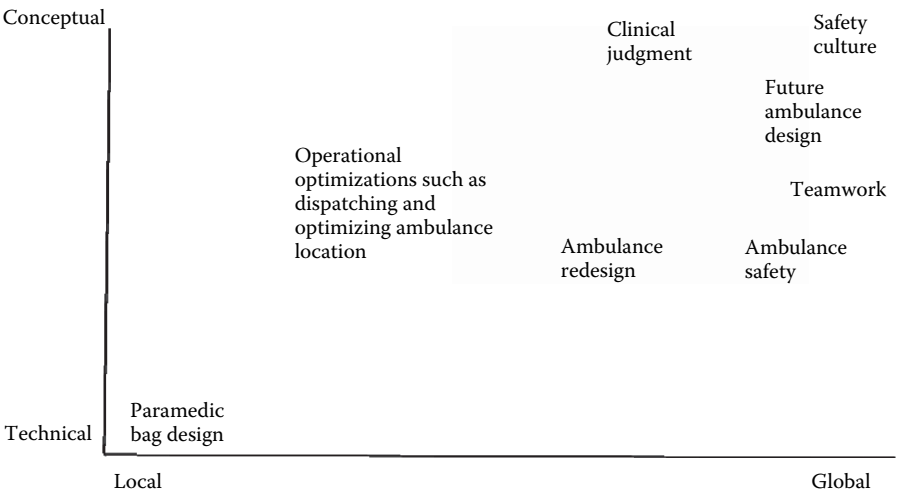
The origin of the patient safety movement described earlier in this chapter is based on the understanding that the gap between the working environment and human capabilities is the source of many of the safety incidents in healthcare. This understanding led the way to many projects that involve human factors not only in incident investigation, but also in designing new systems.

As with other elements of change in healthcare, these projects started primarily in hospitals, and although paramedic work is a critical component of the healthcare system, it has not been the recipient of adequate research investments.

Human factors-related projects that were done in paramedic services have mainly targeted the safety of paramedics and patient care. These include, for example, safety culture surveys, human factors-informed procurement, improving teamwork and working procedures, working environment design, medication safety, and more. Some of these projects have been implemented in local services and others in regional services that cover a number of local services. Other projects incorporated

larger research and were aimed at implementing global improvements at the level of the entire industry. Local projects are usually smaller in size and scope and are done with local resources and budget, while bigger projects are done by research centers and manufacturers. Figure 12.2 shows a schematic view of how human factors-related projects in paramedic services are covering both the technical and conceptual aspects of paramedics' safety and patient care, while the solutions that they provide can be applied to specific local services or to the global paramedics' community.

Examples of some of the current projects include studies on ways to improve teamwork (Lazzara et al., 2015) and redesign of the paramedic response bags (Bitan et al., 2015) and are changes that could reduce the chances for mistakes in medication, as described in the "Introduction." Figure 12.3 demonstrates new paramedic response bags that were developed in Northumberland (Ontario, Canada). Other projects target the ambulance interior design, which has not changed much since World War I. Current projects to design the future ambulance apply user-centered design tools to redesign the back of the ambulance in a way that will better fit the paramedics' needs. These projects are done both as research projects to test new concepts (such as Redesigning the Emergency Ambulance from the Helen Hamlyn Centre for Design, Royal College of Art) and as a commercial solution such as Ferno 2020. Projects that aim to improve the technical part of the work paramedics do bring new equipment that carries patients (such as chairs and stretchers). These projects focus the design on technical solutions that will reduce the paramedic physical burden and add features that are more ergonomically and safety designed. Many of these projects are still at a stage of research and have not yet been implemented, but when they are implemented in paramedic services, this may also facilitate their implementation into other areas in healthcare, which may benefit from the lessons learned in this smaller-scale modification.



**FIGURE 12.2** Level of human factors projects in paramedic services.

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**FIGURE 12.3** New paramedics’ response bags, a project that was done in Northumberland (Ontario, Canada).

Despite the fact that paramedic services and other healthcare systems are different in many ways, there are important similarities across both systems, which enable the transfer of knowledge acquired in implementing modifications in paramedic services to other healthcare systems. Although projects done in paramedic services are typically of a smaller scale, lessons can be learned from these projects and can teach us how to use human factors tools and methods in larger-scale systems. For example, starting a quality improvement project by working with a group of paramedics to study the way that things currently work in the field, design the recommended improvement, and carefully plan the implementation stage can teach us a lot about the challenges of implementing such projects in a hospital. Learning from the experience of the paramedic services will serve as a pilot for a larger-scale implementation.

**WHAT IT TAKES FOR PARAMEDIC SERVICES TO LEAD HUMAN FACTORS IMPLEMENTATION IN HEALTHCARE**

In order to become leaders in implementing human factors tools and methods to improve patient safety, paramedic services should embrace discovery and innovation. Programs that encourage paramedics to initiate and participate in safety improvement and research projects should be promoted. Such changes should begin from the

level of the management that has to show leadership by facilitating and encouraging these projects. This management focus will lead to a culture shift toward embracing change and innovation even at the cost of difficulties along the path.

Improvements and modifications of equipment and processes cannot be designed by outsiders. One of the key features for success in such projects is getting the paramedics involved in the process. The paramedics will inform the process by providing valuable information from their own experience in the field and participating in interviews and observations. Importantly, their involvement in the design phase will increase the compliance during the implementation phase (Bitan et al., 2015). One element which can promote this initiative is including a research component as part of the paramedic training requirements. This goes in line with the fact that many paramedics receive their training through college degrees. Including research as part of the paramedic college studies would introduce them to concepts of evidence-based improvements and will develop a working environment of professionals who plan change and act upon it based on collected data. One group that had a significant impact on the implementation of human factors in healthcare more generally was that of anesthesiologists, who were seeking solutions for the technical challenges that they faced in their work. Paramedics can take a similar role in leading human factors change in healthcare. This will include not only being actively involved in projects but also participating in discussions, being present in conferences, and publishing in professional journals. By becoming a leading force in human factors projects in healthcare, paramedic services not only will have the benefit of developing a safer working environment but will also change the safety culture in this community to become a community where strive for change and improvement is part of its DNA.

## SUMMARY

Paramedic service is a domain that has unique characteristics among healthcare organizations. These characteristics allow paramedic services to implement improvements faster and more easily. These improvements can reduce the chances for safety incidents such as the one described in the “Introduction.” In addition, sharing the experience of such projects with other healthcare organizations will make the paramedic services a leading force in this complex domain.

Paul Raftis, the Toronto Paramedic Services chief, highlighted the change in the paramedic services world: “Today’s paramedics are college graduates, highly educated and highly trained in pre-hospital paramedicine that is life-changing and life-saving. These paramedics use modern, state-of-the-art technology and clinical best practices, to help our patients when they need it most. These changes have evolved the Paramedic Service so significantly since the 1970s that the two are barely recognizable when compared to each other” (Toronto Paramedic Services, June 2015). Adding research and quality improvement projects as one of the areas where paramedic services can develop will benefit the paramedic services and will allow them to become a test bed for implementing human factors in the healthcare system.

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