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Review Article

Riding to the Rescue: A Comprehensive Review of Health and Safety Measures in Ambulance Cars

Almaazmi AM[1*], Alhammadi SH[1*], Al ali AA[1], Alzaabi NI[1], Makoukji J[1#]

[1]Higher Colleges of Technology, Faculty of Health Sciences, Sharjah Women Campus, Sharjah, United Arab Emirates
*These authors contributed equally to this work

Corresponding author:
Joelle Makoukji Kiklikian, PhD
Higher Colleges of Technology, Sharjah Women Campus, Faculty of Health Sciences, University City Road, Sharjah, United Arab Emirates
Telephone: +971 2 206 6291
Fax: +971 6 558 5435
Email: jkiklikian@hct.ac.ae
ORCID ID: https://orcid.org/0000-0001-7343-4801

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ABSTRACT

Paramedics are registered health professionals in numerous countries. Whilst ambulance services must prioritize their patients, they also require personnel to be healthy to perform at their utmost to provide optimal patient care.

Ambulance transport is associated with predictable and likely preventable occupant hazards. These include injuries, serious infections, high rates of musculoskeletal diseases, stress, and mental health problems.

This review article aims to identify the occupational risks in an ambulance service, assess their impact on the health of employees, and explore control measures that can be implemented to reduce the risks and improve the safety of healthcare workers and patients. It underscores the significance of implementing robust risk management strategies to safeguard the well-being of EMS professionals and their patients. Drawing from established risk management principles, it offers insights into hazard prioritization and control measures. It emphasizes the importance of proactive measures such as ergonomic design, infection control, and noise reduction, as well as the need for ongoing training and support for EMS workers.

Ultimately, this comprehensive review article explores the hazards associated with ambulance work across different income-level countries and offers practical solutions to enhance the safety and effectiveness of this critical healthcare service.

Keywords: Control measures, Emergency medical service, Hazards, Occupational health and safety, Risk factors.

Introduction

The word "ambulance" has its origin in the Latin word ‘ambulare’, which means ‘to walk or to move about’. In medieval times, the term ‘ambulant’ was used to refer to a hospital that provided medical care to patients who could still walk or move around.[1]

In the early modern period, the French adopted the word ‘ambulance’ to describe a military field hospital that was staffed by trained medical personnel and used to provide emergency medical care and transport for wounded soldiers. This concept of the ambulance as a mobile medical unit was later adopted by other countries, and the term ‘ambulance’ became widely used to refer to a vehicle used for transporting sick or injured people. In the mid-19th century, civilian ambulance services began to emerge, particularly in urban areas where horse-drawn carriages were used to transport patients to hospitals. In the late 19th and early 20th centuries, motorized ambulances became more common, and ambulance services began to be organized on a

more formal basis. During World War I and World War II, advances in medical technology and transportation led to significant improvements in the care of injured soldiers, and many of these advances were later adapted for civilian use.[1]

Nowadays, ambulances are equipped with a wide range of medical equipment and are a critical component of emergency medical services (EMS) around the world. Ambulance personnel are essential first responders in the community, providing rapid and life-saving advanced medical care to patients in need, during transport to hospitals or other medical facilities. Across different countries, they are known by a variety of terms such as paramedics, emergency medical technicians, emergency medical personnel, emergency dispatch personnel and call-takers. Their role is to directly provide or coordinate the communication of response for out-of-hospital or pre-hospital emergency medical care in the community.[2]

However, working in an ambulance car can be a hazardous occupation, exposing healthcare workers and patients to a variety of potential risks. These hazards can include traffic collisions, biological hazards, ergonomic hazards, noise, and emotional stress. The risks associated with these hazards can have serious consequences for the health and safety of both healthcare workers and patients. Therefore, it is important to understand the potential hazards and risks associated with working in an ambulance car and to implement appropriate control measures to minimize the risk of harm.[3]

In this review article, we will examine the hazards associated with working in an ambulance car, whether in low-, middle- or high-income countries and explore the control measures that can be implemented to reduce the risks and improve the safety of both healthcare workers and patients.

Risk management in the ambulance car

EMS professionals treat approximately 22 million patients each year in the United States of America (USA), and most of the care delivered by EMS involves ambulance utilization, whether transporting patients to the hospital or responding to a call.[4] The ambulance can be a challenging work environment, with potential hazards to both patients and healthcare providers.[5] The out-of-hospital setting is unique to health care and presents many challenges to providing safe, high-quality medical care in emergencies. The challenges of the prehospital environment require thoughtful design of systems and processes of care. Risk management (RM) is a formalized proactive process that has been used in a range of occupational settings, including firefighting and mining, to reduce workplace hazards and injuries.[6] Organizations use formal RM to manage risks and hazards through identification, assessment, and prioritization of risks for mitigation and intervention. RM follows a cyclical set of three phases, including hazard scoping, risk assessment, and implementation of controls within a feedback loop (Figure 1).[6]

ISO 31000 is a risk management standard published by the International Organization for Standardization (ISO). It was first released in 2009 and offers a collection of recommendations designed to help firms streamline risk management. The risk management process typically begins with a risk assessment. Included in the risk assessment is the identification of risk, an analysis of the risk, and an evaluation of that risk. Following the risk assessment, an organization will decide what risk treatment to approach and then monitor and review the risk and results. Fundamentally, the risk management process endeavors to identify risk and then implement a management system to minimize the chance of that risk occurring or, if the risk does occur, to reduce its harm and assure a speedy recovery.[7]

The goal of this review article is to apply risk assessment processes in an ambulance car to identify risks and hazards associated with EMS practices and determine potentially effective control measures.

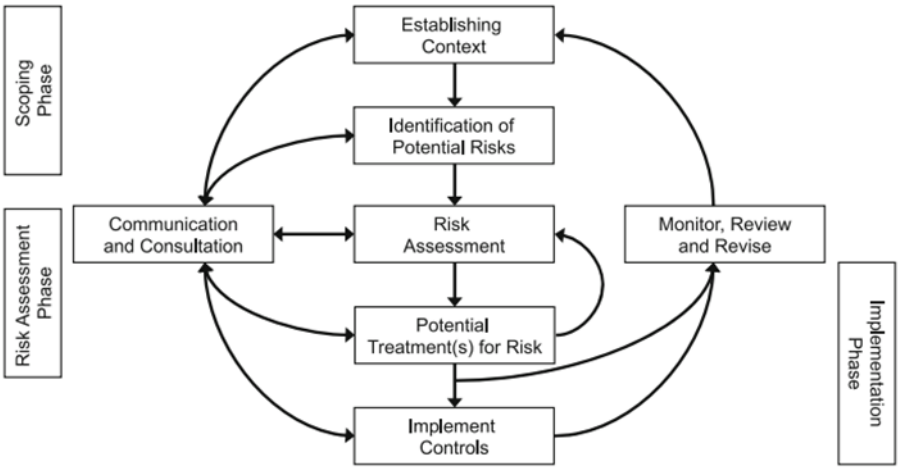

Figure 1: An overview of the Risk Management process, adapted from ISO 31000:2009.[6]

Risks and hazards identified in the ambulance car

EMS personnel encounter a hazardous and difficult work environment in a moving ambulance while providing lifesaving and life-sustaining emergency patient care. The most common occupational hazards in an ambulance car are traffic accidents and collisions leading to injuries due to emergency response driving; biological hazards due to exposure to pathogenic microorganisms leading to serious occupational infections such as hepatitis B and C or Acquired Immunodeficiency Syndrome (AIDS); ergonomic hazard leading to physical strain and musculoskeletal injuries due to unsafe patient handling; physical hazard such as noise in ambient work environment which may cause harm and stress to workers; and psychological hazard leading to occupational stress, burnout and fatigue among ambulance personnel (Table 1).

Table 2: Summary of hazards and their potential associated risks

Hazards	Associated Risks
Emergency Response (Lights & Siren)	Traffic accidents & collisions leading to injuries
Biological Hazard (Pathogens)	Nosocomial infections, Infectious diseases like Human Immunodeficiency Virus (HIV), Hepatitis B, and Hepatitis C
Ergonomic Hazard (Physical strain)	Musculoskeletal Disorders (MSDs), Chronic pain
Physical Hazard (Noise)	Noise-Induced Hearing Loss (NIHL), Stress
Psychological Hazard (Stress)	Mental health issues, Post-traumatic stress disorder (PTSD)

Emergency response driving is cited as a major risk factor in many studies. Custalow and Gravitz reported that 91% of emergency vehicle collisions in Denver occurred under lights and sirens, and the association is driven by generally higher speeds and reduced reaction times during emergencies.[8] High speeds reduce the driver's ability to react to hazards, to safely control the vehicle, and to navigate traffic. A growing body of research demonstrates that ambulance crashes are common. Deadly events may be preventable with attention to the ambulance's external design and the internal configuration of the rear compartment.[9]

Ambulances can conceivably be a potential source

of different pathogenic microbes by virtue of their role in transporting patients from a scene to a healthcare facility. Not only the patients but also the paramedical staff and relatives of the patients may be exposed to various pathogens, some of which may cause serious infections and diseases.[10] A regional study examined the levels of bacterial contamination in Welsh ambulances over 12 months on a monthly schedule. The results showed a variety of microbes at unacceptable levels were present in the samples before cleaning of emergency vehicles, re-emphasizing the need for more stringent infection control programs.[11] Another study also showed that the EMS ambulances of the Kingdom of Saudi Arabia (KSA) can carry pathogenic bacteria that are hazardous to the paramedical personnel, as well as, to the patients that are transported within these ambulances. The pathogens isolated, such as Bacilli, Staphylococci, and Enterococci can pose a substantial risk for nosocomial infections, not only for patients who have weak immune systems but also for personnel. In addition, these pathogens can also be transmitted to new patients or relatives who may travel along with the patient.[10]

Paramedics can be exposed to blood when treating trauma victims who may be experiencing uncontrolled bleeding. Exposure of paramedics to blood can also occur from a sharp injury, such as a needlestick after use on a patient or a cut from a contaminated sharp object while performing advanced life support procedures under unpredictable, adverse conditions. A national survey of paramedics was conducted in the USA, between 2002–2003, to measure the incidence of exposure to blood among paramedics. The survey showed that 22% of paramedics had at least one exposure to blood in the previous year.[12,13] The sharps injury rate for paramedics was also high compared with most hospital workers. Also, exposure of broken skin to blood was extremely high among paramedics. Human Immunodeficiency Virus (HIV), Hepatitis B Virus (HBV), and Hepatitis C Virus (HCV) are all bloodborne pathogens that are transmitted through broken skin; thus, these exposures should be medically evaluated immediately (some treatments, such as for HIV exposure, should be started as soon as possible, preferably within hours). Infected workers who remain undiagnosed could place other people at risk of infection.[14]

In an attempt to ensure timely treatment for their patients, paramedics often place their bodies in high-risk situations. This means paramedics make choices to lift, pull, or push heavy loads all the time. As a result, paramedics have one of the highest overall risks for musculoskeletal injuries among healthcare workers. Roberts et al. demonstrated that paramedics had between 3.5- and 13 times greater risk of lower back injury compared to nurses.[15] In the USA, ergonomic risk factors, such as excessive physical effort, awkward postures, or repetitive movements, were the leading causes of injuries amongst EMS workers, of which 90% were attributed to lifting, carrying, or transferring a patient and/or equipment.[16]

Noise is a ubiquitous potential hazard to our bodies. The World Health Organisation reported that 16% of hearing loss in adults is attributed to occupational noise.[17] Noise-induced hearing loss (NIHL) is a sensorineural hearing loss, explained by a permanent threshold shift of hearing sensitivity. International standards recommend an 'equivalent sound pressure level of 85 dB(A) at 8-h working day average as the exposure limit for occupational noise', to preserve the personnel's hearing when working in a noisy environment. Several studies gave evidence that noise creates physical and psychological stress, commonly presented as reduced assessment, sleep disturbances, cardiovascular dysfunction and mental health alteration. Ambulance service workers are exposed to noise during their shifts in ambulance vehicles, and the noise level varies during signal and non-signal trips, and with different speed levels.[18] A study showed that the Latvian and German ambulance service personnel demonstrate an exposure to hazardous noise level of approximately 85–90 dB(A) during signal trips, which reaches and partly exceeds the exposure limits of 85 dB(A).[19] Another study also

demonstrated that the noise exposure levels among prehospital personnel in Denmark exceeded the recommendations described in the European Regulative for Noise (>80 dB(A)). Although no evidence of occupational hearing loss was demonstrated in the EMS personnel, however a reduced function of the outer sensory hair cells was found in the EMS group following missions.[20] High noise levels can also contribute to serious workplace accidents and injuries. Noise can reduce workers' awareness of what is happening around them, including signals, alarms, and verbal warnings. Studies show that repeated exposures to sounds that are 85 A-weighted decibels (dBA) or higher can cause stress and fatigue, as well as several health problems including ringing in the ears (tinnitus), high blood pressure (hypertension) and cardiovascular disease.[21]

The nature of ambulance work, the uncontrolled and often unpredictable environments, the everyday experience of trauma, and the cumulative nature of that trauma all play a key role in the development and impact of mental distress and psychological injury among EMS personnel.[22-24] In addition to the nature of the work, organizational and occupational factors such as workload, work demands, shift work, limited time for debriefing or downtime, the hierarchical nature of supervision, and the lack of recognition are clearly shown to have effects on the well-being of ambulance personnel that are as significant as, if not greater than, the nature of the work itself. Moreover, several studies have addressed the prevalence of post-traumatic stress disorder (PTSD) symptoms in ambulance services to be much higher than in the general population.[25]

		Hazard Effect/Consequences			
		1 (Minor)	2 (Moderate)	3 (Major)	4 (Maximal)
		First aid case; exposure to minor health risk; little to no economic costs incurred.	Medical treatment; lost time injury; reversible impact on health; exposure to major health risk; economic costs are low.	Loss of quality of life; irreversible health impact; economic costs are moderate.	Single/Multiple fatalities; health impact is ultimately fatal; economic costs are high.
Likelihood		Risk Ranking			
4 (Almost Certain)	The incident occurs with regularity and will continue to occur (>75% likelihood)	7 (M)	11 (H)	14 (EX)	16 (EX)
3 (Likely)	The incident has occurred frequently, and is expected to occur (30-75% likelihood)	4 (L)	8 (M)	12 (H)	15 (EX)
2 (Possible)	The incident has happened at some time (infrequently), and will occur under some circumstances (10-30% likelihood)	2 (L)	5 (M)	9 (M)	13 (H)
1 (Unlikely)	The incident has happened in the past (rarely), and may occur in exceptional circumstances (<10% likelihood)	1 (L)	3 (L)	6 (M)	10 (H)

Figure 2: Hazard matrix used in ranking and prioritizing risks and hazards identified in the ambulance car.[6]

Ranking and prioritizing risks and hazards identified in the ambulance car

The risks and hazards in the ambulance car were prioritized and ranked using a risk matrix approach commonly employed in formal risk assessments. Risk matrices rank hazards based on a product of two domains: the likelihood of the considered hazard to occur; and the severity of bodily injury or harm produced if the hazard occurred.[26] An ordinal likelihood score is assigned

for each hazard on a scale from 1 (unlikely) to 4 (almost certain). Severity was qualitatively assessed and scored on an ordinal scale from 1 (minor) to 4 (maximal) (Figure 2). Risks with a ranking of 1 – 4 (in green) were assigned as 'low priority', 5 – 9 (in yellow) as 'medium priority', 10 – 13 (in orange) as 'high priority', and 14 – 16 (in red) as 'extremely high priority' (Figure 2). Risks and hazards ranked as 'high' to 'extremely high' should be prioritized first for immediate intervention.

The above-mentioned hazards have been evaluated based on their severity and likelihood and assigned a risk level. Based on the risk assessment matrix (Figure 2), the highest priority hazards are emergency response, biological hazard, and ergonomic hazard, all of which have been assigned a 'high risk' level (Table 2). These hazards should be addressed with particular attention and resources to minimize the risk of harm to patients and healthcare workers.

Table 2: Summary of hazards, potential risks, and their priority ranking

Hazards	Potential Risks	Severity	Likelihood	Risk Level
Emergency Response (Lights & Siren)	Traffic accidents & collisions leading to injuries	**Major**	**Likely**	**High (12)**
Biological Hazard (Pathogens)	Nosocomial infections, Infectious diseases like HIV, Hepatitis B and C	**Major**	**Likely**	**High (12)**
Ergonomic Hazard	MSDs, Chronic pain	**Moderate**	**Almost certain**	**High (11)**
Physical Hazard (Noise)	NIHL, Stress	**Minor**	**Likely**	**Low (4)**
Psychological Hazard (Stress)	Mental health issues, PTSD	**Moderate**	**Possible**	**Medium (5)**

Control measures to reduce the risk

Before discussing control measures to reduce the potential risks, it is important to take a step back and think about the hierarchy of controls. Occupational Safety and Health Administration (OSHA) considers the hierarchy of control, as a way to determine what controls would be feasible and most effective (Figure 3).[27]

- Eliminate: This is the preferred method and most effective solution. It is controlling the hazard at the source.
- Substitute: If elimination is not possible, consider substituting or replacing the known hazard with a material, process, or equipment that is less hazardous.
- Engineering controls: A strategy involving denying access to the hazard by installing physical barriers. This could be a redesign of equipment or work processes to reduce the frequency of performing dangerous tasks. Or the isolation of the hazard by installing screens or barriers around hazardous areas.
- Administrative & work practice controls: When exposure to the risk is not, or cannot be

minimized by other means, you should introduce safe work practices, as well as training and education in order to reduce the risk.

- Personal Protective Equipment: Introduce PPE to increase protection and when other measures are not practical.

To prevent hazards associated with working in an ambulance car, healthcare workers should implement control measures that can reduce the risk of exposure to potential hazards (Table 3).

Figure 3: Hierarchy of control.[27]

Table 3: Summary of selected control measures to reduce the risks associated with hazards in the ambulance car

Hazards	Potential Risks	Control Measures
Emergency Response	Traffic accidents & collisions leading to injuries	Modification of rear compartment, secure equipment in place, use seatbelts and helmets, education about traffic laws, follow safe driving practices, use driving assistance technology
Biological Hazard	Nosocomial infections, Infectious diseases like HIV, Hepatitis B and C	Frequent fumigation techniques, use of safety devices, use appropriate personal protective equipment, follow infection control standard procedures
Ergonomic Hazard	MSDs, Chronic pain	New ergonomic design of rear compartment, use lifting equipment and proper body mechanics, job rotation and take regular breaks to rest and stretch
Physical Hazard	NIHL, Stress	Wear appropriate hearing protection (ear muffs or earplugs), turn off unnecessary alarms and sirens, active noise reduction, better insulation of ambulances
Psychological Hazard	Mental health issues, PTSD	Social support systems, receive regular debriefings and counselling, education on stress management techniques

Unfortunately, conventional ambulance designs have been suboptimal and often place EMS

personnel in health-compromising situations, contributing to their high rates of injury, fatality, and early retirement. For example, conventional ambulances were not conducive to seatbelt usage because the patient and supplies were out of reach for seated and restrained EMS personnel. Further, the limited work surfaces resulted in EMS personnel using their seats or their patients' bodies to hold supplies, including sharps. Both the unrestrained EMS personnel and supplies could become dangerous projectiles in a collision and could result in serious injuries.[16] Failure to use current methods of occupant protection for each occupant or to secure equipment effectively can result in catastrophic outcomes for all occupants. Therefore, attention must be given to modifications to the rear compartment, including rounded corners on cabinets, straps to secure equipment thereby preventing projectiles, and the installation of airbags. Results of crash tests showed that EMS personnel and patients in the rear compartment have to be restrained by seatbelts and that seatbelts should even be worn when administering care. The patient should be always restrained by a vacuum stretcher because the risk of expulsion and impact against a sharp corner of a storage compartment is high. Medical equipment and stretchers in the rear compartment are an additional risk during a crash and fixations must be stronger than belts and tested in crash tests. It would be preferable if each piece of medical equipment was provided with a quick-release system. Seatbacks should be placed parallel to the road and secured by seatbelts anchored in three points. There is an urgent need for the dissemination of this safety information and to development of data-driven performance-based safety standards and designs.[28] Education and knowledge are also critical elements in the prevention of ambulance crashes. One study indicated that EMS personnel may not possess adequate knowledge of traffic laws pertaining to driving an ambulance with lights and sirens. Technology is making significant inroads into assisting drivers in carrying out their duties. Notably, several investigators have explored driver monitoring and feedback systems to help change dangerous driving behavior. Devices are available that can alert drivers entering intersections to the presence of other vehicles, notify them when they are too close to a vehicle (to prevent a collision), and warn drivers when they are about to run off the road.[9]

A study confirmed the importance of evaluating the frequency and efficiency of various fumigation techniques as an ambulance is a potential reservoir for microbial transmission to patients and staff. Comprehensive education and infection control programs that help in understanding disease transmission and the etiology of infections are important for paramedics. This will decrease the transmission of nosocomial infections due to better infection control processes by all the staff and cleaning personnel. There is a definite need for stricter implementation of ambulance disinfection programs with more frequency. Many occupationally acquired infections can be limited by proper awareness programs, training initiatives, and stringent guidelines for ambulances.[10] Studies show that 80% of needlestick injuries involved the use of non-safety devices by EMS personnel, and the main predictor for the use of safety devices was whether employers provided them. Major factors for eye and nose exposures to blood included: the patient vomited, spit, or coughed; the patient was uncooperative, combative, or being resuscitated; or the blood/body fluid splashed. Although more than 80% of paramedics said their employers provided safety goggles and face/surgical masks, most splashes to the eye or nose occurred when protection was not used. Paramedics need more training on how to use personal protective equipment (PPE), better-designed PPE, or additional PPE to protect themselves. Note that paramedics had significantly fewer exposures to blood if their supervisors emphasized following Standard Precautions and if paramedics were evaluated on following safety procedures.[14]

Carpal tunnel syndrome, tendinitis, rotator cuff injuries, muscle strains, and other work-related musculoskeletal disorders (MSDs) such as these can be prevented. By implementing ergonomic

solutions in the workplace, you can help reduce the number and severity of work-related MSDs. The standard ambulance's interior design is unsatisfactory based on perceived discomfort and postures that constrain paramedics and medical staff, resulting in unsafe treatment of patients, mainly when being transported. In order to increase risk prevention, ergonomically optimized stretchers should be utilized. Several concrete changes in the design of the ambulance are also recommended in order to reduce the extraordinarily high strain on the paramedics and to increase the safety and user-friendliness of the system during a rescue operation. The new ergonomic design should aim to less effort needed during the transport of the patient, which, at the same time, means lower physical strain on the paramedics' backs and their hand–arm–shoulder systems. Where engineering controls are unable to be implemented, it may be appropriate to consider administrative or work practice controls that establish efficient processes and procedures, such as requiring a two-person lift when materials exceed a certain weight or are awkward in shape/size, and establish a job rotation system to minimize the duration of continual exertion, repetitive motions, and awkward postures, allowing the employee to use different muscle groups.[29]

Education of the ambulance workers about preventive measures to reduce noise hazards, the importance of NIHL development and its health risks, as well as regular audiometry check-ups, are needed. Moreover, there are several ways that noise levels can be monitored such as using personal protective devices like filter-type earplugs, planning to avoid streets of bad quality, which produce excessive noise or need prolonged signal use due to crowded traffic, acoustic insulation and soundproofing to doors, walls and ceilings, and positioning sirens as far away as possible from the personnel, e.g., front of the spoiler.[19] If elimination or reduction of the noise to a safe level is not possible, simple changes in scheduling and operations can significantly decrease the total amount of noise exposure for each worker. Examples of administrative control measures that can be implemented include adapting work procedures to minimize the number of workers exposed to noise and the duration of their exposure, and training workers to be aware of noise hazards, providing them with strategies to limit exposure, and encouraging them to avoid activities which would increase their exposure.[21] The most stressful emergencies according to paramedics are critical and traumatic situations such as road accidents, emergencies with children, family members, or other people they know, and situations where the location is unknown or there is not enough information about the situation. The majority of ambulance personnel must be able to deal with potentially traumatic events reasonably well, and they use different strategies depending on the moment and the situation. Nonetheless, social support is an important protective factor against the negative effects of potentially traumatic events and occupational stress. Besides family and friends, the support given by work colleagues and supervisors is an important emotional support source and may reduce the severity of PTSD symptoms, burnout, and psychological distress. Another strategy to cope with emotional stress is to promote among EMS personnel, through training and educational sessions, health habits and psychosocial skills, such as communication skills, psychological first aid, stress management, teamwork and decision-making skills.[30]

Conclusion

In conclusion, the ambulance system, by the wide range of services it provides and the increasing number of accepted claims, is a job characterized by multiple occupational health hazards for its employees and patients. These hazards include traffic accidents due to emergency response, biological hazards, ergonomic hazards, noise, and emotional stress. To prevent harm to healthcare workers and patients, it is important to implement control measures to reduce the risk of exposure to these hazards. Control measures can include following safe driving practices, using appropriate personal protective equipment, using

lifting equipment and proper body mechanics, and receiving regular debriefings and counseling.

By using a risk assessment table and risk assessment matrix, it is possible to identify and prioritize the hazards and control measures needed to reduce the risk of harm. By addressing the highest priority hazards, healthcare workers can improve their safety and the safety of their patients, and reduce the risk of accidents, injuries, and other health problems associated with working in an ambulance car. The identification of risk factors is part of an extensive technical-administrative and educational prevention program; occupational safety and health training for workers must aim to prevent specific hazards and risks.

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