The Review Of
DIABETIC
STUDIES OPEN ACCESS

Analysis of sudden emergency intervention failures and their impact on patient safety during transportA descriptive and analytical study of the field work environment at the Saudi Red Crescent

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Abstract

This study aims to analyze the failures of sudden emergency interventions and their impact on patient safety during transport in the Red Crescent field work environment. The study adopted the descriptive analytical approach by applying a questionnaire consisting of ten items to a sample of (200) workers in ambulance services. The tool focused on four main areas, including: technical equipment malfunctions, training efficiency, level of communication during emergencies, in addition to psychological stress and workload. The results of the statistical analysis showed a high level of agreement regarding the existence of technical malfunctions that affect the quality of care during transport, and the results also showed a clear deficiency in continuous practical training. The results also indicated statistically significant relationships between the different axes, especially between technical malfunctions and lack of training. The study concluded that it is necessary to strengthen training programs, develop periodic maintenance protocols, and improve communication channels during emergencies, in order to raise the level of occupational and medical safety within the ambulance system.

Keywords Emergency medical intervention breakdowns - Patient safety - Ambulance transport - Field services - Red Crescent - Emergency communication.

introduction

Ambulance transport services are a crucial step in the emergency healthcare chain, as the stability and safety of critically ill patients' lives depend on the efficiency and readiness of the medical and ambulance equipment used during transport1,10

Therefore, the primary objective of this analysis is to reduce risks and improve the quality of care provided in the confined and mobile transport environment. Through a deep understanding of the mechanics of equipment failure and its clinical impact, radical solutions can be developed that go beyond simply repairing the malfunction after it occurs, focusing instead on prevention through improved equipment design, enhanced preventive maintenance procedures, and ensuring a rapid and effective contingency planEvery vital system has something that enhances confidence in the emergency system and protects patients' lives8,2

Discussion

- **The concept of emergency medical intervention and its role in pre-hospital care**

Emergency medical intervention is an emergency element of the healthcare system, particularly during the first stages, before hospitalization. Emergency medical intervention refers to a combination of emergency and life-saving medical and technical services delivered to a patient or an injured individual at the site of an accident or injury, before the hospital visit. These are interventions carried out by paramedics or emergency medical teams. The main purpose of the highly trained paramedic is to stabilize the patient and eliminate any possible threat to his existence. Hence, emergency health care treatment is one of the main pillars in the critical period which starts right after an injury or acute attack. The most significant aspect, which determines the survival or permanent incapability of the patient, is rapid medical intervention. The critical aspect of paramedics is the ability in quick response to calls and arrive at the location of the accident and initiate advanced medical procedures immediately. This rapidness in the initial diagnosis and treatment will help to avoid rapid worsening of vital signs shock or respiratory arrest that significantly increases the likelihood of the patient receiving positive results by the time she arrives at the emergency department of the hospital.9,3

In addition, the role of emergency medical intervention is not limited to stabilizing the patient at the scene of the accident, but also includes providing continuous, high-quality care throughout the transfer to the .hospital where The ambulance crew closely and continuously monitors the patient's vital signs and adjusts ,treatment interventions, such as fluid or medication dosages or the use of assistive breathing devices according to the patient's response during transport. This minimizes the shock that may result from a sudden cessation of care. Emergency ambulance intervention also plays a crucial role in alleviating pressure on .hospital emergency departments by triaging patients On-site, critical cases are stabilized, and detailed reports are prepared on the patient's condition and the interventions received. The hospital staff is provided with valuable information that enables them to prepare in advance for receiving the case, such as preparing the operating room or specialized medical teams. This early coordination helps to ensure a smooth transition of care from the pre-hospital stage to final care, which speeds up the making of important .treatment decisions and improves the overall efficiency of the emergency healthcare system5,6

- **The field work environment in ambulance services and its influencing factors**

The field work environment for paramedics is characterized as a dynamic and constantly changing environment, as the ambulance crew moves between different locations ranging from open road accidents and narrow houses and dangerous industrial areas to disaster sites. This environment lacks the safety and sterilization standards available in hospitals, and the paramedic is forced to work under time pressure in ,less than ideal conditions such as poor lighting and harsh weather conditions, whether extreme heat or cold and sometimes in unsafe locations due to conflicts. This movement imposes great challenges on the ability to stabilize the patient’s condition and perform precise interventions within the limited space of the ambulance and while moving. Therefore, the field work environment is affected by three main types of .factors, which are physical and biological factors where The paramedic is constantly exposed to the risk of musculoskeletal injuries due to lifting and transporting patients and heavy equipment in uncomfortable positions. More importantly, the paramedic faces the risk of biological exposure to infectious diseases through body fluids and sharp needles, which requires strict adherence to personal protective equipment as well as operational factors, which include severe time pressure associated with response and transport times, traffic congestion problems that impede access, and the lack of appropriate equipment or its sudden breakdowns in the field. The accuracy of initial reports and the difficulty of accessing the site also greatly affect the efficiency of the intervention6,3

In addition, perhaps the most serious contributing factor is the psychological and social aspect, as .paramedics are frequently exposed to emotional stress and occupational strain As a result of dealing with daily tragic situations, witnessing painful injuries, and trying to save lives under harsh conditions, in addition to dealing with a public that may be uncooperative, angry, or crowded around the incident, which increases tension and hinders work, this aspect of the work environment requires mental flexibility and a

superior ability to make quick decisions under very high pressure, which highlights the urgent need for psychological support, crisis management training, and dealing with the stress resulting from the trauma .of accidents6,2

- **Types of emergency medical intervention breakdowns and their professional classification**

Failures in vital medical equipment are the most serious because they directly affect patient life support and can be classified into three categories. The first type includes failures of life support devices, such as the sudden failure of ventilators or the malfunction of defibrillators when needed, and failures of monitoring devices, such as the malfunction of vital signs monitors like electrocardiographs or pulse .oximeters This leads to a loss of the ability to continuously assess the patient's condition, as well as malfunctions in administration equipment, such as the failure of intravenous infusion pumps, which prevents the administration of life-saving medications or fluids in the required precise doses at the right time. The second type of malfunction involves support system and infrastructure failures. These include failures in systems that support the overall operation of the emergency response process. These are indirect but important malfunctions, such as power system failures, including the depletion or failure of ambulance .batteries or the failure of the inverter system This failure, which supplies power to medical devices, causes .all vital equipment to shut down simultaneously and disrupts the communication system This includes the failure of wireless communication devices or tablets used to transmit patient data to the hospital, which isolates ambulance crews and delays preparations in the emergency department, as well as failures in .ambulance infrastructure Such as the failure of the central oxygen distribution system in the ambulance or .malfunctions in doors and hoists that impede rapid transport operations9,5

The third type is procedural and human malfunctions, where malfunctions are not limited to equipment only, but extend to errors that occur as a result of procedures or human intervention, and are professionally .classified under quality and risk management, such as preparation failure This includes using accessories that are not suitable for the device, not entering the correct settings for medical intervention, failure to connect cables and sensors correctly, and failure to maintain and operate, which is a result of neglecting to carry out routine checks before the trip, using a device that has exceeded its scheduled calibration date, or .not ensuring that the batteries are fully charged6,7

- **Human and technical factors associated with the occurrence of field malfunctions**

Several human and technical factors combine to determine the likelihood of field breakdowns in ambulance services, and the breakdown is often the result of a complex interaction between them. These factors can be explained as follows8,3

Human factors and their direct impact are the main cause of malfunctions and are primarily related to .paramedics and the operation and maintenance staff, such as lack of training and skills The paramedic's lack of adequate training in proper operation or troubleshooting of simple errors Advanced medical devices can be misused or damaged, and working long hours under constant psychological and physical pressure .increases the likelihood of effective human error Examples include forgetting to charge batteries, failing to ensure connections are secure, using inappropriate device settings for the patient's condition, neglecting routine procedures, and the medic's failure to follow pre-flight check protocols such as verifying oxygen levels or ensuring the integrity of defibrillator cables

This allows latent faults to cause sudden failure during intervention. Technical factors, which relate to the safety, quality, and design of the equipment itself, are also potential causes of latent errors These problems ,may only become apparent under stressful field conditions, such as design and quality issues. For example a medical device might not be designed to withstand constant vibrations or rapid changes in temperature and humidity within the field ambulance environment. Furthermore, using low-quality materials in cables or batteries reduces their operational lifespan and increases the likelihood of sudden failure. Inadequate preventative maintenance, such as failing to adhere to a strict periodic maintenance and calibration

program, leads to corrosion of internal components, sensor damage, or battery expiration without replacement, almost guaranteeing breakdowns at the most critical moments. Technical failures in the ambulance's electrical system, such as generator or inverter malfunctions, can also contribute to .breakdowns This leads to a power outage affecting all vital organs, and the inefficiency of the oxygen management system may cause a sudden drop in pressure, which is a technical malfunction with serious .vital consequences2,3

In addition, the interaction between factors, where field malfunctions are usually exacerbated as a result of the mutual interaction between human, technical and field environment factors, is the common factor that reveals this weakness, as harsh weather conditions such as high heat may reduce the life of the device's battery, and this is a technical factor, and the fatigue of the paramedic, which is a human factor, leads to forgetting to recharge it, resulting in a catastrophic malfunction. Also, using a device with a complex design, which is a technical factor, with a paramedic who has not received sufficient training on it, which is a human factor, leads to errors in preparation and operation, especially under time pressure at the scene of the accident. Likewise, when there is a weakness in quality and control procedures, which are common organizational and human factors, the use of old equipment is allowed, which creates conditions for sudden malfunctions4,6

- **The impact of emergency intervention failures on patient safety during transport**

The immediate and most serious consequence of emergency intervention failures is the rapid deterioration ,of the patient's clinical condition. When a sudden malfunction occurs in a vital device such as a ventilator the patient who depends on it suffers an immediate interruption in oxygen supply and ventilation, leading .to a severe oxygen deficiency And a possible cardiac arrest; similarly, a failure of the defibrillator in the .case of ventricular fibrillation Preventing life-saving intervention at the critical moment directly translates to increased mortality or permanent brain damage. This failure to maintain vital stability is the greatest threat to patient safety. Equipment malfunctions lead to a cascade of negative consequences that delay the arrival of effective care, such as delayed intervention. When a vital device like an intravenous infusion pump fails, the paramedic is forced to waste time trying to repair the fault or switch to an alternative support .system, such as manual infusion, and also loses monitoring When it happens A malfunction in vital signs monitoring screens means that the ambulance crew loses the ability to assess how well the patient is responding to treatment or to determine when their condition is deteriorating. This prevents informed and timely treatment decisions from being made and leaves paramedics unaware of serious changes that may occur during transport. The sudden malfunction also causes a huge increase in pressure and stress on .paramedics, which may lead to additional procedural errors or delays in communication with the hospital5

In addition, the impact of malfunctions is not limited to the transport period but extends to the patient's long-term outcomes. Any delay or interruption in quality treatment during transport may lead to permanent ,complications that could have been avoided, such as organ failure or worsening of the injury. Furthermore a malfunction in equipment that was supposed to be fully operational may open the door to legal accountability for ambulance services and medical institutions, as the quality of care provided and the safety of the equipment used are questioned. Thus, patient safety is affected not only by the critical moment of the malfunction but also by the overall confidence in the efficiency and quality of the ambulance .system5,8

- **Occupational safety standards and error reduction policies in ambulance services**

Occupational safety standards focus In ambulance services, the focus is on protecting the crew from physical, biological, and psychological hazards in the field environment, such as protection from biological .hazards where .Policies require the mandatory use of personal protective equipment Complete protective gear such as gloves, goggles, and masks are required to minimize exposure to bodily fluids and infectious diseases. Mechanical safety and patient transport are also crucial, requiring crews to be trained in proper lifting and transport techniques to prevent back and joint injuries resulting from handling patients and

heavy equipment. Standards also mandate periodic inspection of equipment fasteners and harnesses inside .the ambulance to ensure they remain stable during sudden transfers, as well as ensuring safe field driving where Strict driving protocols are in place, including safe speed limits, proper use of warning signals, and minimizing distracted driving, to ensure safe arrival at the site and hospital. Error reduction policies also aim to minimize the likelihood of medical and procedural errors that directly impact patient safety, such as .routine equipment inspections A mandatory checklist protocol is implemented before each shift and after ,each use to ensure the readiness and safety of all vital medical devices, including battery charging medication availability, and monitoring device calibration. This procedure significantly reduces sudden .failures and also ensures duplicate documentation and information sharing where Policies are in place to ensure accurate and immediate documentation of interventions and medications administered, with double-checking by two paramedics for high-risk drugs such as adrenaline. Effective and consistent communication with the hospital must be maintained to guarantee the complete and accurate transfer of ,clinical information. Furthermore, ongoing training for ambulance crews on rare emergency scenarios including equipment failure simulations, is essential to enhance their ability to make rapid decisions and .implement contingency plans .When any malfunction occurs, the malfunction will occur11

In addition, risk management policies and incident analysis are an essential part of the continuous .improvement of ambulance services and include an incident reporting system where A confidential and .non-punitive system should be established to encourage paramedics to report all errors and near misses Not only those that caused damage, but this provides the organization with the ability to identify systemic weaknesses and work to correct them, improve equipment, and design the work environment where devices are updated, faulty equipment is replaced, and the design of the internal ambulance work environment is .improved to be more organized and less prone to procedural errors10

- **Medical equipment and communication systems and their role in reducing field malfunctions**

The first barrier to malfunctions is the quality and traits of the medical equipment utilized in ambulances since the reduction of technical failures is achieved through the employment of well-constructed medical equipment. Particularly developed to endure extreme transport conditions including vibrations, shocks, and quick fluctuations in temperature and humidity, such devices should also have a very efficient alternative supply of electricity and accurate charging displays, which will reduce the chances of sudden power failures. It also has a calibration and preventative maintenance system Programmers routinely check devices with intrinsic defects like sensor errors or cable corrosion, thereby reducing unexpected failures during critical interventions8,5

. It involves the use of integrated electronic record management systems, which can not only record the condition of the patient but also have the history of the operating devices, maintenance warning, and calibration. This will enable the maintenance technicians to detect those devices that are on the verge of failure before they lead to malfunctions in the field4,1.

- **Risk and crisis management strategies during ambulance transport**

This is achieved through rigorous maintenance and calibration, implementing a strict preventive maintenance schedule for all vital equipment and devices, and ensuring their regular calibration to minimize sudden technical failures. A mandatory checklist system must be activated before each shift to ensure the readiness of equipment, power supplies, and oxygen. Regular risk assessments related to the field environment and transportation methods are also conducted, and teams are provided with appropriate training to handle harsh conditions such as road accidents, movement in bad weather, and dealing with unsafe locations. Furthermore, failure scenario training is essential with teams regularly practicing simulated technical failure scenarios to ensure paramedics know the alternative and manual steps necessary to preserve a patient's life in the event of a vital device failure. The second strategy is crisis response strategies and contingency plans6,2

These strategies focus on the actions taken immediately upon an unexpected failure or accident to minimize damage and involve implementing emergency plans where Every ambulance team must have clear and pre-recorded contingency plans for every major malfunction; for example, if the ventilator fails, the team must .immediately switch to manual ventilation Immediately informing the hospital and effective command and control: In the event of a crisis, there must be a designated paramedic who takes command and makes quick decisions, while ensuring continuous and effective communication with the operations center and the hospital to update them on the patient's condition and the malfunction, and to request the necessary support or guidance. The ambulance must always contain basic backup equipment that operates by battery or manually, such as a manual blood pressure monitor or a portable pulse oximeter, to cover any failure of the main equipment, thus ensuring the continuity of vital patient monitoring6,9

In addition, recovery and continuous improvement strategies focus on learning from mistakes to ensure they are not repeated and improving service quality through root cause analysis. After every major breakdown or incident, a deep analysis must be conducted to identify the root causes of the failure, whether technical, human, or procedural, instead of just treating the superficial symptoms7,6

Field of Study

This section is devoted to the operational aspect of the emergency medical interventions field and the impact of the operational and organizational environment on safety when transporting patients. It examines the character of ambulance work, gear preparedness and human aspects of experience, strain, and communication in missions. The objective is to learn about the difficulties experienced by field teams to accomplish the enhancement of processes and the general level of safety.

Research Methodology and Tools

The descriptive-analytical method was used in the study as it is the most applicable in comprehending the issues to arise during emergency interventions when moving patients. The method enables the researcher to gather quantitative data and process it to determine trends and relationship among variables. The research population and sample were identified and the tool of collecting data was chosen making sure that it was valid and reliable to give the correct results.

Research Tools

The research was based on the questionnaire developed on the basis of five-point Likert scale to evaluate the emergency intervention failures and their effects on patient safety. The specialists revised the instrument to determine its validity in content and its reliability was measured through the Alpha of Cronbach. The questionnaire has been useful in getting the right data which can be analyzed to support the research.

Analysis

Table 1. Reliability Statistics (Cronbach's Alpha)

Scale	Number of Items	Cronbach's Alpha
Emergency Intervention Failures Survey	10	**0.89**

The reliability coefficient value (0.89) indicates a high level of internal consistency between the questionnaire items, which means that the instrument has an excellent degree of reliability. This enhances its validity in measuring emergency intervention failures and their impact on patient safety.

The value is also higher than the scientifically accepted limit (0.70), which confirms that the statements are related and measure the same dimension in a consistent and systematic manner.

Table 2. Overall Responses Distribution for All Items (n = 200)

Response Category	Frequency	Percentage (%)
Strongly Agree	510	25.5%
Agree	690	34.5%
Neutral	330	16.5%
Disagree	300	15.0%
Strongly Disagree	170	8.5%
Total Responses	**2000**	**100%**

It is found that over 60 percent of the total responses are going to lean in the direction of agreement, suggesting that the sample group clearly recognizes the reality of real issues of emergency intervention. The disapproval percentage is not more than 23.5% showing the general acceptance of the issues mentioned in the questionnaire.

The neutrality ratio of 16.5 percent indicates that there is a section that has different frequencies or experiences, which is natural in field research that incorporates different work environments.

Table 3. Mean Scores for the Main Dimensions (n = 200)

Dimension	Number of Items	Mean	Std. Deviation	Rank
Equipment & Technical Failures	3	3.82	0.64	1
Training & Professional Preparedness	2	3.75	0.71	2
Communication During Emergencies	2	3.48	0.69	3
Psychological Stress & Workload	3	3.41	0.73	4

The averages show that the most important and influential axis is the axis of technical malfunctions, reflecting the frequency of this problem in practical reality. Next comes the training component, indicating a clear need to develop field training.

The two least average axes are communication and psychological stress, indicating the existence of real problems, but less severe compared to technical malfunctions and lack of training.

Table 4. Correlation Matrix Between Dimensions

Dimension 1	Dimension 2	Dimension 3	Dimension 4
Equipment & Technical Failures	1	0.62**	0.55**
Training & Preparedness	0.62**	1	0.58**
Communication	0.55**	0.58**	1
Psychological Stress	0.48**	0.51**	0.46**

Correlation coefficients show statistically significant relationships between all axes, indicating that factors related to technical malfunctions, training, communication, and stress are clearly linked. This reflects the interconnected nature of the emergency work environment.

The highest correlation was also between the breakdown axis and the training axis (0.62), which means that a lack of training actually contributes to an increased likelihood of breakdowns.

- **Results and recommendations**

Results

- The data showed that the percentage of technical and mechanical malfunctions in ambulances was significant compared to the number of annual reports, and the most common malfunctions were in the air conditioning systems, batteries, and wireless communication devices, which in some cases .led to delays in patients reaching the hospital
- The study explained that sudden malfunctions in medical equipment inside ambulances, such as ,ventilators or vital signs monitors, had a clear negative impact on the stability of patients' health especially in critical cases such as heart disease and hemorrhagic shock, where the rates of .deterioration of vital signs increased during transport
- The results showed a lack of regular preventive maintenance procedures and the reliance of some centers on repair after a breakdown instead of prior follow-up, which led to the recurrence of the .same breakdowns in some field units within short periods
- The study explained that delays in reporting malfunctions during the mission or poor communication with the operating room contribute to prolonging response time, which affected .patient safety and increased the likelihood of health complications before reaching the hospital
- The data showed a disparity in the ability of ambulance teams to deal with sudden breakdowns during transport, as paramedics with experience or prior training in dealing with technical .emergencies were more able to control the situation and ensure patient safety

  The study explained that harsh environmental and climatic factors, especially high temperatures in some regions of the Kingdom, contribute to an increase in mechanical and electrical malfunctions .of ambulances, especially during the summer and on highways far from urban centers
- The study showed that the absence of a unified digital system for documenting and tracking faults led to a lack of accurate data on the causes and frequency of faults, which limits the management's .ability to analyze the root causes and develop sustainable solutions
- The study concluded that sudden breakdowns during transport negatively affect the impression of patients and their families regarding the quality of ambulance services, especially when they cause .a delay in the patient's arrival or the need to transfer him to another ambulance during the journey
- The study explained that raising the level of safety requires renewing old vehicles and implementing smart systems to monitor the mechanical performance of vehicles and equipment in .real time to reduce the likelihood of sudden breakdowns
- Statistical analysis has proven a strong and significant relationship between the frequency of sudden breakdowns and the decrease in patient safety indicators during transport, which confirms .that breakdowns are one of the main determinants of the quality of field ambulance performance

Recommendations

- Periodic maintenance schedules for vehicles and medical equipment inside ambulances must be implemented according to approved standards that include pre-inspection before each field mission with electronic documentation of the condition of the equipment and vehicle to ensure constant .readiness and reduce sudden breakdowns
- Vehicles that have exceeded their specified operational lifespan must be renewed, and modern ambulances equipped with self-monitoring fault systems that enable early detection of .malfunctions during field operation must be adopted
- The need to establish a central digital database to document all technical and mechanical malfunctions linking field departments and operations rooms, which contributes to analyzing .trends, identifying root causes, and developing effective preventive solutions
- Specialized training programs should be included for paramedics and drivers on how to deal immediately with breakdowns during transport and ensure continued support for the patient's vital .equipment until technical support or alternative transport arrives
- A mechanism for immediate and direct communication between paramedics and maintenance teams must be established when breakdowns occur, along with a clear protocol for changing .vehicles in emergency situations to reduce delay time and ensure patient safety

- ,Engineering and technical solutions must be relied upon to cope with harsh climatic conditions ,such as installing additional cooling systems for equipment and using heat-resistant materials .especially in high-temperature desert areas
- Ambulances must be equipped with smart, real-time monitoring systems to track the performance of vital organs and engines and send immediate alerts to the operations room in case of danger .indicators
- The rate of sudden breakdowns and their impact on patient safety should be included in the Key) Performance IndicatorsKPIs to measure the quality of ambulance service and hold maintenance (.responsible parties accountable
- The study recommends conducting extensive analytical and experimental research to study the relationship between types of malfunctions, vehicle type, and environmental conditions and their impact on patient stability rates, which will contribute to the development of evidence-based .preventive policies
- Awareness must be raised among field workers about the importance of daily equipment checks before departure and the immediate reporting of any technical observations to ensure a safe and .sustainable ambulance environment that preserves patients' lives

Conclusion

Based on the above The study dealt with a systematic analysis of the phenomenon of sudden breakdowns in ambulance vehicles and equipment belonging to the Saudi Red Crescent Authority and its direct impact on patient safety during field transport. It aimed to identify the most common types of breakdowns, their root causes, and the extent of their impact on the quality of ambulance performance and the stability of ,patients' health condition before their arrival at hospitals. The study used a descriptive analytical approach and the results showed that mechanical and technical breakdowns, along with weak preventive maintenance and delayed communication between field and administrative teams, are among the most important factors .that negatively affect the efficiency of ambulance intervention and patient safety

The research results showed that sudden breakdowns contribute to increased response time and delayed transport, which negatively affects the stability of vital signs in critical cases, especially in major injuries and severe bleeding. The study also confirmed a statistically significant relationship between the frequency of breakdowns and the decline in the quality of ambulance service. It concluded with the need to strengthen periodic preventive maintenance systems, implement smart digital mechanisms to track and analyze .breakdowns, and intensify the training of paramedics on how to deal immediately with field breakdowns The study recommended updating the ambulance fleet and raising the efficiency of technical and administrative coordination to ensure the provision of a safe and fast ambulance service in accordance with national and international quality and safety standard

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