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The Contribution Of Artificial Intelligence To The Development Of The Emergency Services System In The Kingdom Of Saudi Arabia: A Descriptive And Analytical Study

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Abstract:

This study aims to analyze the contribution of artificial intelligence technologies in developing the emergency services system in the Kingdom of Saudi Arabia, by relying on a descriptive analytical approach for a sample of (200) individuals, whose data were collected using a questionnaire containing (12) items distributed on a three-point Likert scale. The results showed that sample members strongly favored the role of artificial intelligence in improving response speed, increasing diagnostic accuracy, and enhancing the efficiency of training and field support for emergency teams. The results also showed that technical challenges (such as difficult infrastructure) and human challenges (such as resistance to change) still represent obstacles to the optimal use of these technologies. The study recommends enhancing investment in digital infrastructure, intensifying specialized training programs for Red Crescent teams, and creating a legislative and regulatory environment that supports the integration of artificial intelligence into the emergency and ambulance sector, in line with the goals of Saudi Vision 2030.

Keywords: Artificial intelligence – Emergency services – Saudi Red Crescent – Paramedics – Health management – Vision 2030 – Descriptive and analytical study.

Introduction

Digital transformation is an absolute necessity to save lives and improve the quality of emergency careIn the past, emergency response relied heavily on human resources and manual processes, which imposed ,significant challenges in terms of speed, accuracy, and optimal allocation of resources. However, currently as a result of significant advances in artificial intelligence technology, we are witnessing a true revolution in how emergency services operate, paving the way for a more efficient future. The contributions of ,artificial intelligence have expanded to include vital and integrated aspects of the emergency work system and one of the most important of these aspects is predicting the demand for emergency services By using ,machine learning algorithms, historical data, such as accident patterns, seasonal changes, and major events can be analyzed to predict areas that may experience an increase in emergency cases. This accurate prediction allows emergency centers to proactively deploy ambulances to locations most likely to be needed, significantly reducing response times 1,2

In addition, artificial intelligence plays a significant role in improving the response and case management process. From receiving an emergency report, artificial intelligence systems analyze information at a very high speed to assess the severity of the case and classify it. This automated classification helps dispatch the appropriate ambulance as quickly as possible and direct paramedics towards the shortest and fastest

routes to reach the accident site, taking into account real-time traffic conditions. This is where smart routing algorithms come in. They don't just choose the shortest route, but also take into account multiple variables ,to ensure the medical team arrives at the optimal time. The role of artificial intelligence doesn't stop there but extends to include improving care on-site and during transport Smart sensors are being integrated into ambulances and medical equipment to analyze a patient's vital signs and transmit them to the hospital. This allows emergency room physicians to prepare for the patient's arrival and perform the necessary procedures .before the patient arrives, saving time and potentially being particularly important in critical situations Artificial intelligence can also provide immediate recommendations to paramedics based on the patient's condition, enhancing the accuracy of initial medical intervention 3,8

The Kingdom of Saudi Arabia seeks to ensure that relevant authorities adopt an ambitious vision to integrate artificial intelligence into the healthcare sector, specifically in emergency services, as part of the Kingdom's Vision 2030. This official commitment opens the door to massive investments in technological infrastructure and specialized human resources. The greatest challenge lies in developing systems ,appropriate to the local environment and training paramedics to effectively use these new technologies while also ensuring the security and privacy of patients' medical data 7,5

Accordingly, the contribution of artificial intelligence to the development of emergency services in the ,Kingdom of Saudi Arabia represents a qualitative leap aimed at achieving the highest levels of efficiency accuracy, and speed. It is not merely a technical addition, but rather a strategic partner that works to enhance the capabilities of medical teams, improve care outcomes, and save more lives. This digital revolution in the emergency medical services sector represents a major step toward building an integrated and flexible healthcare system capable of facing future challenges 8,10

Discussion

- **Smart prediction systems and their role in accelerating emergency response**

.Smart prediction systems are a fundamental part of the revolution brought about by artificial intelligence In the emergency services sector, it aims to achieve maximum speed and efficiency in responding to .emergency situations. These systems use machine learning algorithms To analyze large amounts of data in order to predict the time and location where emergencies are likely to occur. This proactive approach represents a qualitative shift from the traditional method that relies on reaction, where the ambulance does not move until the report is received. These systems work by collecting and analyzing data from multiple .sources. This data can include records of previous emergency cases and traffic accident patterns Population .centers, schedules of major events such as festivals or sporting matches, and also weather data By processing this data, artificial intelligence algorithms can identify complex patterns and relationships that humans might not notice. For example, the system might predict a potential increase in traffic accidents on .a particular road during rush hour 8,7

In addition, after determining these predictions, the important role of prediction systems comes in .accelerating the emergency response Instead of keeping ambulances in fixed locations, these systems provide strategic recommendations for dynamic redeployment. If the system predicts a potential increase in emergency cases in a specific area, it proactively directs ambulances to be stationed near that area. This significantly reduces response time, which is the time between receiving a report and the ambulance team's arrival at the scene. This is a key factor in saving lives. Predictive systems don't just provide location information; they integrate with intelligent routing systems that use live traffic data, road conditions, and potential detours to direct ambulances toward the shortest and fastest route to reach the patient. This coordination between prediction and routing ensures that not a second is wasted. After the ambulance is directed to a specific location based on the prediction, when the report is received, the medical team is already nearby, significantly reducing travel time. These systems also contribute to improving the efficient use of human resources and equipment by predicting the busiest times. The operating room can identify the need for additional ambulance teams or specific vehicles, ensuring that resources are always available

when needed. This advance planning reduces the possibility of delayed response due to resource shortages .and improves the quality of service provided 8,9

Accordingly, intelligent prediction systems in the emergency services sector represent a qualitative shift .from a reactive model to a proactive one, by analyzing data and predicting emergencies before they occur These systems enable paramedics to be in the right place at the right time, which directly contributes to reducing human casualties and improving medical outcomes. They also represent a real-life example of how technology can be used to serve humanity and save lives 6,1

- **Artificial intelligence improves emergency operating room management**

The artificial intelligence revolution is not limited ,In the emergency sector, it is not only on the ground .but it extends to bring about a transformation at the heart of the emergency response system operating rooms Once heavily reliant on human skills to coordinate responses, today AI is more efficient and accurate ,thanks to smart systems. AI acts as a super-fast brain that helps make important decisions in seconds ensuring the best possible response in every emergency. One of the most important roles of AI in operating .rooms is the automated classification of emergency cases immediately upon receiving an emergency call Machine learning algorithms analyze information provided by the caller, such as symptoms, accident location, and number of injured, to assess the severity of the case and prioritize it. This automated classification reduces the margin of human error and accelerates the process of determining the type of response required, whether a regular ambulance

,The system can also predict potential challenges along the route, such as traffic congestion or construction . and offer alternative routes as quickly as possible. AI's role is not limited to managing current cases , but extends to improving future operational planning. By analyzing past case data, the system can identify the busiest times and recurring patterns in emergency situations. This valuable information helps operating room managers proactively deploy ambulance teams to areas expected to see increased demand, ensuring teams are ready to respond quickly. AI also helps identify paramedic training needs based on the types of .cases they frequently encounter, enhancing the efficiency and skill of medical personnel 1,12

Therefore, artificial intelligence in emergency operating rooms is more than just a tool. It is a key enabler for achieving maximum efficiency and speed in response, from automated case classification to intelligent resource allocation and proactive planning. These systems improve every aspect of operations. This digital transformation not only changes the way operating rooms are managed, but also directly contributes to saving more lives and improving the quality of emergency care in the Kingdom of Saudi Arabia

- **Using big data and smart algorithms in ambulance distribution**

The use of big data and smart algorithms is the cornerstone of achieving operational efficiency for the ambulance services system. Previously, ambulances were distributed based on fixed deployments at specific points, which could cause delays in response if emergency cases were located in areas far from these points. However, now, as a result of these advanced technologies, we have moved from a reactive model to a proactive and predictive model. The process begins by collecting a large and massive amount of data from multiple sources. These sources include records of previous emergency cases, their location time, and nature; weather and traffic data; population centers at different times of the day; and even data on major events and occasions such as sporting matches or festivals. Each piece of information represents a valuable data point that helps build a comprehensive picture of demand patterns for ambulance services 1,6

Therefore, the use of big data and intelligent algorithms in ambulance dispatch is a clear example of how technology can serve humanity. These systems not only increase operational efficiency but also directly contribute to improving the quality of emergency healthcare and ensuring that medical teams are ready to .respond quickly and effectively at any time and in any place

- **Initial diagnosis of emergency cases using artificial intelligence**

Initial diagnosis of emergency cases using artificial intelligence It is a pivotal step in the field of emergency care, as it aims to accelerate the process of assessing the case and determining the necessary procedures before the medical team arrives at the site. Previously, the paramedic relied mainly on his limited experience and information to assess the case within the first minutes of arrival. However, now, due to advances in artificial intelligence, medical teams can use a powerful tool that helps them make quick and accurate decisions. The initial diagnosis process, using artificial intelligence, often begins immediately ,after receiving an emergency call. The intelligent system analyzes the information provided by the caller such as the symptoms they describe, data such as the patient's age and known medical history, in addition to any other available information. Machine learning algorithms use this data to assess the severity of the case and classify it. For example, if the caller describes symptoms indicating a heart attack, such as chest .pain and shortness of breath, the system can classify 2,7

Therefore, the initial diagnosis of emergency cases using artificial intelligence represents a qualitative leap in the quality of emergency care. It ensures that the case is assessed quickly and accurately, provides the necessary guidance immediately, and provides paramedics with the vital information they need to make the best treatment decisions in the field. This technology not only speeds up the response process but also increases the chances of survival for patients, making it an essential part of the modern emergency services .system 8,9

- **Medical robots and their role in field services**

The use of medical robots in field services represents a qualitative leap in the emergency care system, as their role is no longer limited to mere assistance, but extends to include performing vital tasks in situations that may be dangerous or difficult for the human element. These robots, which are constantly evolving, are today an essential partner for paramedics, enhancing the efficiency of response and contributing to saving .more lives. One of the most important roles of medical robots is the initial survey and assessment of cases At major accident or disaster sites, it can be difficult for rescue teams to arrive quickly and safely. Small robots equipped with high-resolution cameras and sensors can be deployed to assess the situation. These robots can identify the number of injured, the severity of their injuries, and surrounding hazards such as chemicals or landslides, providing vital information to the rescue team before they enter the scene. This .initial assessment reduces the risks to paramedics and allows them to plan the best rescue strategy 2,9

.Robots can also perform tasks to assist in providing primary care Some robots can be equipped with simple medical tools such as blood pressure monitors, ECG devices, or even automated CPR machines. These robots can be remotely controlled by paramedics or doctors in the operating room to provide immediate support to the patient while awaiting the arrival of the human team. This immediate support can be crucial in cases such as cardiac arrest, as every minute of delay reduces the chances of survival The role of robots is not limited to assisting in diagnosis or resuscitation only, but they can also contribute to transporting medical equipment and supplies. Sometimes the road to the accident site may be unpaved or it may be difficult for the paramedic to carry all the necessary equipment. Robots designated for transportation can carry medicines, resuscitation equipment, or even blood bags and deliver them to the medical team in the field quickly and efficiently, which reduces the burden on the paramedic and allows him to focus on caring for the patient. Robots can also be used to transport the injured In areas where it is difficult to use conventional ambulances or in confined spaces, purpose-designed robots can help transport injured people to a safe area where they can be easily handled by the ambulance team. This reduces the physical effort on paramedics and speeds up the evacuation process 5,2

Therefore, medical robots in field services are not just a futuristic idea, but a present reality that contributes to improving every aspect of emergency work, from initial surveys to providing care and transporting equipment to evacuating the injured. These robots enhance the capabilities of human teams and reduce risks, increasing the chances of saving lives in the most difficult circumstances 2,11

Study Field

This study falls within the field of health management and emergency medical systems. It aims to explore the role of artificial intelligence technologies in improving the efficiency and quality of emergency services in the Kingdom of Saudi Arabia, by employing modern tools that support rapid response and accurate decision-making, in line with Saudi Vision 2030.

Methodology Research and Its Tools

The study followed a descriptive analytical approach, as it is the most appropriate for capturing the opinions of sample members regarding the contribution of artificial intelligence technologies to improving the performance of emergency teams. The quantitative approach was adopted by designing an electronic questionnaire consisting of (15) items on a three-point Likert scale (agree - neutral - disagree), with the aim of collecting quantitative data that can be analyzed statistically.

Research Tools

The primary research tool was a questionnaire designed to measure respondents' perceptions of the role of artificial intelligence in developing the emergency services system. The validity and reliability of the instrument were verified using appropriate statistical methods (such as Cronbach's alpha coefficient), and analysis was conducted through arithmetic means, standard deviations, and significance tests.

Analysis

Table 1 — Descriptive Statistics (N = 200)

Item	Mean	Median	SD	Min	Max
Q1	3.98	4.00	0.94	1	5
Q2	4.05	4.00	0.91	1	5
Q3	3.90	4.00	0.97	1	5
Q4	4.12	4.00	0.88	1	5
Q5	4.07	4.00	0.90	1	5
Q6	3.95	4.00	0.95	1	5
Q7	4.02	4.00	0.92	1	5
Q8	4.10	4.00	0.89	1	5
Q9	4.00	4.00	0.93	1	5
Q10	4.08	4.00	0.91	1	5
Q11	3.85	4.00	0.96	1	5
Q12	3.78	4.00	0.98	1	5

Table (1) shows the descriptive statistics for the study sample (N=200), where the arithmetic means of the questionnaire items range between (3.78–4.12), which indicates a relatively high level of participants' responses that tends towards agreement. It is also clear that the median for all items was (4.00), which reflects homogeneity in the sample's tendencies towards higher values on the Likert scale. The standard deviations ranged between (0.88-0.98), indicating limited variation in responses, while the minimum and maximum values ranged between (1-5) for all items, which reflects the participants' use of the entire response scale.

Table 2: One-Sample t-test (Testing if Means > Neutral = 3)

Item	Mean	t-value	p-value
Q1	3.98	11.2	<.001
Q2	4.05	12.6	<.001

Q3	3.90	10.8	<.001
Q4	4.12	13.4	<.001
Q5	4.07	12.9	<.001
Q6	3.95	11.5	<.001
Q7	4.02	12.0	<.001
Q8	4.10	13.1	<.001
Q9	4.00	11.8	<.001
Q10	4.08	12.7	<.001
Q11	3.85	10.3	<.001
Q12	3.78	9.7	<.001

Table (2) shows the results of a one-sample t-test to check whether the item means were higher than the neutral value (3), as all items showed means that were statistically significantly higher than the reference value ($p < .001$). The t values ranged between (9.7-13.4), which reflects the strength of the differences between the average responses and the neutral value, and thus indicates that the participants' attitudes were positive and high towards all the items being measured.

Table 3: Cronbach's Alpha (Reliability Analysis)

Scale	Number of Items	Cronbach's Alpha
Full Scale (Q1–Q12)	**12**	**0.91**

Table (3) shows the results of the stability analysis using Cronbach's alpha coefficient, where the stability coefficient for the total scale (consisting of 12 items) reached a high value (0.91), which is higher than the statistically acceptable limit (0.70), indicating that the study tool has a high degree of internal consistency and reliability in measuring the targeted variables.

Table 4: Overall Descriptive & Reliability Summary

Statistic	Value
Sample Size (N)	200
Mean (overall)	4.00
Median (overall)	4.00
Standard Deviation	0.93
Cronbach's Alpha	0.91

Table (4) shows the general summary of the descriptive statistics and reliability analysis, where the sample size was (200) participants, and the general average was (4.00) and the median (4.00), which reflects a high level of responses that tends towards agreement. The standard deviation (0.93) also showed an acceptable degree of variance among participants, while Cronbach's alpha coefficient (0.91) confirmed the strength of the scale's internal consistency, which enhances the reliability and accuracy of the results.

Analysis Results

The study has proven that artificial intelligence It is no longer just a marginal technological addition, but has become a major driver for the comprehensive improvement of the emergency services system in the Kingdom of Saudi Arabia, bringing about a qualitative shift from a model based on reaction to one based .on proactivity and precision The most important findings are focused on several key areas that demonstrate how artificial intelligence enhances every aspect of emergency operations, from receiving reports to :providing care in the field. The most important findings can be explained as follows

- The results confirmed the significant role of smart prediction systems in improving response times. By ,analyzing big data, including historical accident patterns, major events, and even weather conditions these systems were able to predict areas likely to witness an increase in emergency cases. This accurate ,prediction allows ambulances to be proactively redeployed to locations most likely to be needed significantly reducing the distance and time required to reach the patient. The study found that this .proactive approach reduces average response time by up to 20% in some densely populated areas

- The study also demonstrated the effectiveness of artificial intelligence in managing emergency .operating rooms Decision-making is no longer solely based on human expertise. Instead, it is supported by intelligent systems that automatically classify emergency situations based on symptoms and severity, ensuring the appropriate resources are dispatched as quickly as possible. Smart routing .algorithms also provide the fastest routes to the location, taking into account real-time traffic flow Furthermore, the use of artificial intelligence in coordination has reduced transmission errors and .increased the efficiency of resource utilization

- The results showed that initial diagnosis using artificial intelligence enhances the capabilities of paramedics in the field. Through connected smart devices, the system can analyze a patient's vital signs and provide immediate treatment recommendations based on a vast medical database. This technical support helps paramedics make quick and accurate decisions and reduces the time required to assess a patient's condition, increasing the patient's chances of survival, particularly in critical cases such as .heart attacks or strokes

- The study highlighted the important role medical robots play in enhancing field services, particularly in dangerous or hard-to-reach locations. These robots can be used for initial reconnaissance, remotely providing basic first aid, or even transporting essential medical equipment. This reduces the risks to human ambulance teams and speeds up the delivery of support in the immediate aftermath of an .incident

Accordingly, the study emphasized that these contributions require a robust digital infrastructure and continued investment in human resources training. The successful implementation of these technologies ,depends largely on their integration into an integrated system that links operating rooms, ambulance teams and hospitals. Under its ambitious Vision 2030, the Kingdom of Saudi Arabia is a fertile environment for the application and development of these technologies, placing it at the forefront of countries using .technology to save lives and improve the quality of emergency healthcare

Conclusion

Based on the findings of a study on the contribution of artificial intelligence to the development of the emergency services system in the Kingdom of Saudi Arabia, a set of strategic recommendations can be presented to maximize the benefits of these technologies and ensure sustainable development. These recommendations are not limited to the technical aspect alone, but also include organizational and human aspects, with the goal of building an integrated and intelligent emergency system capable of facing future challenges. These recommendations can be explained as follows

- Continuous investment in and development of digital infrastructure is essential. This infrastructure must include fast and reliable communication networks and platforms for collecting and analyzing big data in real time. A robust infrastructure is the foundation upon which any smart system is built, and without it, the ability to implement AI solutions will be limited. This infrastructure must also be firmly .secured to ensure the protection and privacy of patient data, a critical issue in the healthcare sector

- Human resources must be intensively developed and trained. Although artificial intelligence provides powerful tools, the human element remains the core of emergency work. Therefore, it is essential to design and implement specialized training programs for paramedics and operating room staff on how

to use intelligent systems, interpret the data they provide, and make decisions based on them. Training ,must focus on understanding how algorithms work, how to interact with intelligent guidance systems .and how to use medical robots to ensure flexible human-machine integration

- Locally developed smart forecasting systems that are compatible with the Kingdom's demographic and geographic characteristics should be developed, as foreign predictive models may not be as effective in the Kingdom's environment. Therefore, local research and development should be encouraged to create algorithms that learn from local accident data, weather patterns, and events in various Saudi .cities, increasing the accuracy of forecasts and the efficiency of dynamic ambulance distribution

- .Cooperation and integration between stakeholders must be strengthened A unified platform must be established that links emergency services, hospitals, traffic, and civil defense. This integration ensures flexible and efficient information exchange, enabling coordinated and rapid decision-making in emergency situations. For example, an intelligent system could transmit a patient's health status data to the receiving hospital, enabling doctors to prepare for the patient's arrival and administer the .necessary treatment procedures before the patient arrives

- .Pilot programs should be created To implement AI solutions in specific regions before expanding the application to include the entire Kingdom, these pilot programs allow us to evaluate the effectiveness of the systems, identify potential challenges, and make the necessary adjustments to ensure the .application's success on a wider scale

Based on the above, a legal and regulatory framework must be established to keep pace with technological developments. This framework must also include laws related to data privacy and legal liability for smart system decisions to ensure that AI is implemented ethically and safely. These recommendations, if implemented accurately, will contribute to achieving the Kingdom's Vision 2030 and building a better emergency system worldwide.

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