Application of Artificial Intelligence in Paramedic Education: Current Scenario and Future Perspective: A Narrative Review

Meshal Menahi Alshebani, Mohammed Qismi Alanazi, Abdulrahman Eidhah Alanazi, Mohammed Abdulrahman Almotlaq, Faisal Mabkhoot ALdawsari, Abdulaziz Mohammed Almeshari, and Abdullah R. Nofal

***Abstract*—Background: Artificial intelligence (AI) has the potential to revolutionise paramedic education. As well as allowing for personalised learning experiences tailored to individual needs and learning styles, it can provide simulations, intelligent tutoring systems, automated grading and assessment, and predictive analytics.**

Objective: To investigate the role of artificial intelligence in transforming the landscape of paramedic education and evaluate its potential to improve learning outcomes.

Methods: This review presented the role of AI in paramedic education and its perspective over the past twenty years. It included high-quality data and comprehensive investigations of articles available in renowned databases.

Results: AI-based training and simulation technologies, such as virtual patients, surgical simulators, and intelligent tutoring systems, are increasingly being used in paramedic education. Virtual patients use computer-generated avatars to display symptoms and react to therapies, while surgical simulators use accurate anatomical models and haptic feedback devices to simulate surgical operations.

Conclusion: AI has the potential to fundamentally alter how students learn, the kind of education they receive, and the efficiency with which healthcare is delivered. It can create immersive training environments, analyse medical data, and help students feel more competent, confident, and capable. This potential can be harnessed to enhance paramedic education and improve patient care outcomes.

***Index Terms*—Artificial Intelligence, Deep Learning, Machine Learning, Medical Imaging, Paramedic Education, Predictive Modelling, Simulation.**

I. INTRODUCTION

Paramedicine is a healthcare profession focused on providing emergency medical services and pre-hospital care.[1] Artificial intelligence (AI), which has increasingly been integrated into the medical field to enhance diagnosis, treatment, and patient care, can provide numerous benefits in paramedic education, such as simulation and virtual reality, diagnostic support, data analysis, and predictive analytics. Simulations and virtual reality can provide realistic scenarios for students to practice their skills in a safe and controlled environment, while diagnostic support can assist with more accurate diagnosis of patients and provide predictions and recommendations to aid in fast, informed decision-making.[2]

Data analysis and predictive analytics can help paramedics analyse large volumes of patient data, such as medical records, vital signs, and previous treatment outcomes. AI-powered decision support systems can identify patterns and trends that humans may overlook, providing paramedics with real-time information and guidelines during emergencies,[3] while personalised learning can adapt to the individual learning needs of paramedic students. Remote consultation and telemedicine can connect paramedics in the field with medical professionals in real time, enabling them to provide more effective care.[4] It can also help identify students at risk of academic under-performance or dropping out, allowing educators to intervene and provide timely support.[5,6]

Meshal Menahi Alshebani, Mohammed Qismi Alanazi, Abdulrahman Eidhah Alanazi, Mohammed Abdulrahman Almotlaq, Faisal Mabkhoot ALdawsari, Abdulaziz Mohammed Almeshari are with the Saudi Red Crescent Authority, Riyadh, Saudi Arabia, e-mail: alshebani8@hotmail.com, e-mail: Mahmoudqismi@gmail.com, e-mail: Phd.100100@gmail.com, e-mail: moh1008844@gmail.com, e-mail: fm.d330@gmail.com, e-mail: i350i@hotmail.com

Abdullah R. Nofal is with the Disaster Management Unit, King Saud University Medical City, Riyadh, KSA, e-mail: aabushaheen@kfmc.med.sa

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AI-powered education can improve knowledge retention and competency, cost and time efficiency, real-world readiness, and continuous improvement, thus addressing the skills gap in the healthcare industry. AI-powered systems can automate tasks such as grading and assessment, reduce the need for expensive physical resources and human mentors, and provide practical skills and experience through AI-based simulations before the trainee enters real healthcare settings.[7,8] AI-powered education can help bridge the skills gap by providing accessible and high-quality training programs, while AI's ability to analyse student data and provide feedback allows educators to continuously improve their teaching methods and curriculum.

Nonetheless, ethical considerations, patient privacy, and data security should remain central, as should human expertise and clinical judgment. Future perspectives include AI in competency assessment, telemedicine education, remote mentoring, and personalised curriculum design. Challenges and ethical considerations must be addressed to ensure responsible and equitable use. [9] Integrating AI into paramedic education can transform the way paramedics are trained and equipped to handle emergencies, allowing them to enhance their skills, improve patient care, and ultimately save more lives.

The aim of this review article was to present the role of AI in paramedic education, its perspective over the past twenty years, its present scenario, and its future applications. This is essential in order to review the existing situation, analyse the benefits and obstacles of AI applications, and bridge the gap between research and practice. Educators, decision-makers, and researchers may learn more about the advancements achieved through incorporating AI into paramedic education by focusing on the present situation, assessing the efficiency of AI applications, and considering future scenarios. This study can also point out the difficulties and limitations associated with incorporating AI into paramedic education, such as technological problems, moral questions, and the requirement for suitable instruction and assistance.

Future advancements in AI-powered paramedic education can be investigated through innovative applications of natural language processing, adaptive learning systems, and real-time data analytics. It is hoped that our evaluation will encourage more improved through AI-based training and ensuring that paramedics have the appropriate training and support to effectively use AI in their practice, the findings can guide curriculum development and policy decisions.

This review can help close the knowledge gap between research and practice by synthesising and disseminating pertinent findings. This will assist in advancing paramedic education to ensure that paramedics have the skills and knowledge required to provide excellent emergency medical care in the AI-driven healthcare environment.

II. METHODS

This study employed a systematic approach to gather relevant literature on the application of artificial intelligence (AI) in paramedic education, focusing on both the current scenario and future perspectives. The research involved a thorough examination of articles published within the last 20 years, available in databases such as Google Scholar, PubMed, and PMC. This study utilised a systematic approach to gather relevant literature on the application of artificial intelligence (AI) in paramedic education, both in the current scenario and future perspectives.

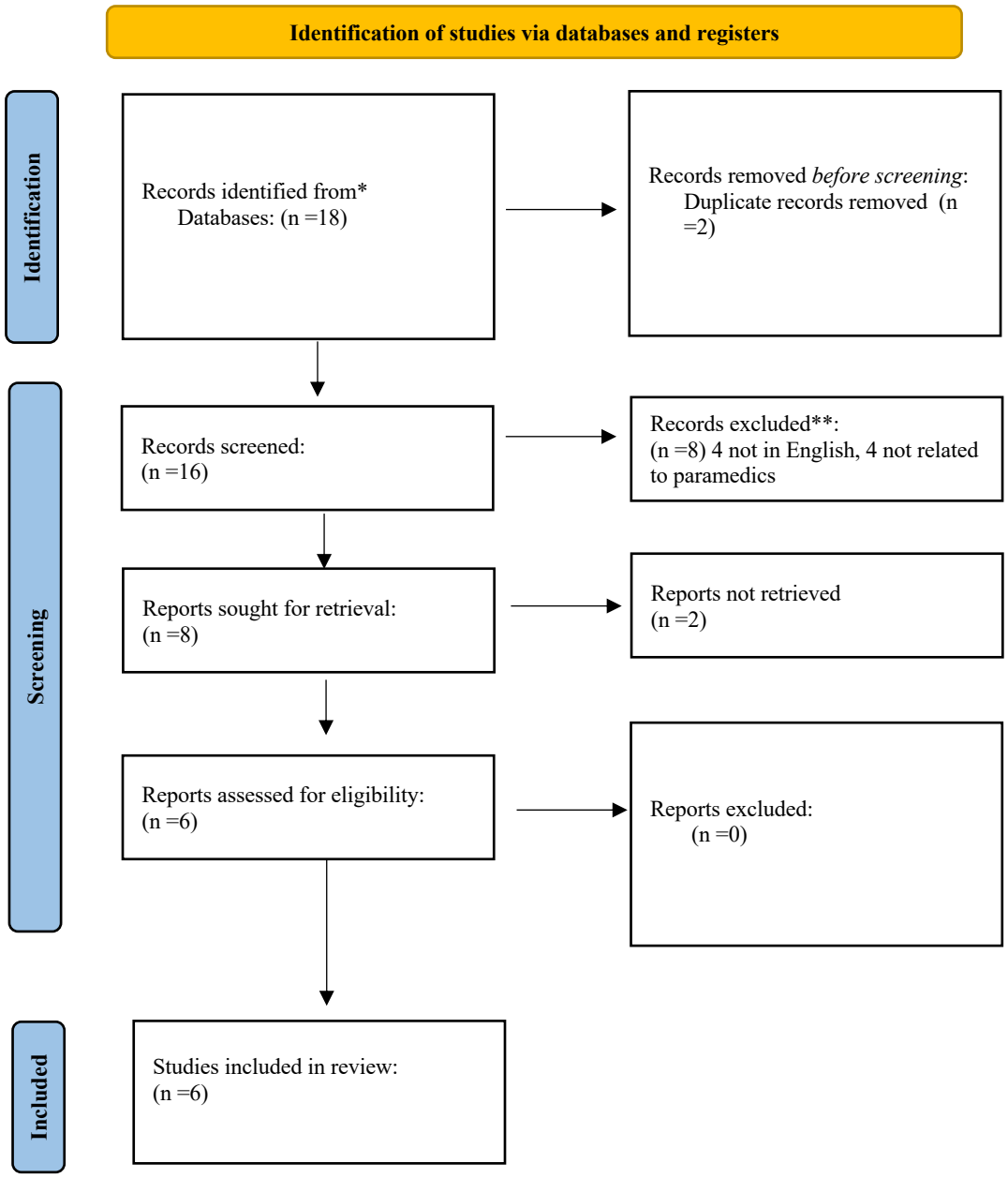
The literature search was conducted using key index words or phrases, including Artificial Intelligence, Machine Learning, Paramedic Education, Deep Learning, Predictive Modelling, Simulation, and Medical Imaging.

Inclusion criteria: Scientific articles addressing the study objectives and written in the English language were included, with a time range of the year 2000 onwards.

Exclusion criteria: Conversely, literature that did not address the role of AI in paramedic education and literature dated before 2000 were excluded. This was done as techniques and models that are currently relevant to paramedic education may not have been adequately developed or explored before the year 2000.

III. RESULTS

We utilised the PRISMA chart [10] to depict the total number of included studies, as shown in Figure 1. Additionally, Table 1 presents a summary of the articles related to artificial intelligence in paramedic education. investigation and cooperation around this developing topic by outlining potential future directions. By identifying the competences and skills that can be



(*): Records were excluded during title and abstract screening for reasons such as not being research articles, lacking relevance to the topic, or being duplicates.
(**) Records were excluded after full-text review due to reasons such as methodological flaws, insufficient data, or not meeting the inclusion criteria.

Figure 1. PRISMA Flowchart

Table1. Summary of articles concerning artificial intelligence in paramedic education

No	Authors	No. of articles/ participants	Year	Description
1.	Birtill et al [7]	11	2021	The study assessed publications on AR/MR in paramedicine education, revealing varying quality. Applications include screen-projection immersive settings, headset-based VR, and computer-based avatar worlds. Cost-effectiveness was explored, but no research covered exposure volume or frequency. Insufficient evidence exists for AR/VR superiority over traditional simulation.
2.	Wheeler et al. [11]	18	2020	Paramedics often use simulation as a primary teaching method, fostering competency and clinical skills while providing real-life experiences and strategies for effective patient care.
3.	Rees et al. [12]		2020	VR is a new instructional tool that has the potential to improve paramedic skill acquisition and maintenance. The authors' research, testing, and scaling-up of this technology began with the ParaVR initiative.
4.	Eggers et al. [13]	41	2020	Early AR software research on cardiac blood flow revealed discrepancies due to funding issues, simplistic renderings, and bugs. However, users actively participated in self-guided conversations. Further research is needed to improve learning and assessment outcomes, including larger samples, in-depth interviews, and evaluations.
5.	Strum et al. [14]	-	2022	Machine learning algorithms could inform point-of-care treatment and more appropriate transport destinations besides emergency departments.
6.	Honda et al. [15]	-	2021	The artificial intelligence-based instructional system for paramedics who specialise in dementia is useful for their line of work.

AR: Augmented Reality; VR: Virtual Reality; MR: Mixed Reality.

The integration and use of augmented reality (AR) and mixed reality (MR) in paramedic education is covered in a scoping review by Birtill et al.[7] Their research discovered a sparse and inconsistent body of data regarding AR/MR in paramedic instruction. Recognised categories of AR/MR comprised screen-projection immersive environments, computer-based avatar worlds, and VR headsets. Their evaluation also emphasised the need for further study on the duration and frequency of exposure necessary to ensure long-lasting effects when employing AR/VR in paramedic instruction.

Wheeler et al [11] emphasise the use of simulation as a paramedic teaching strategy. To create a background for potential future applications, the authors carried out a scoping assessment to look at how this tool is being utilised for paramedic education. Their review found a number of issues covered in the literature, including fidelity, cost, and equipment, skill versus scenario, virtual learning, inter-professional learning, patient safety, and perception of simulation. The research concludes that simulation is a key teaching method that is frequently utilised to instruct and train paramedics, enabling

them to employ pertinent abilities and information in practical settings.

In Rees et al., [12] we learn about the creation of ParaVR, a virtual reality training simulator for maintaining paramedic abilities. The four steps of its development are outlined by the authors: defining needs and specifications, developing an alpha version, developing a beta version, and management. The ParaVR program focuses on preserving paramedics' ability to conduct needle cricothyrotomy and needle thoracostomy, two procedures that are seldom used. The essay emphasises how VR technology might improve the development and maintenance of paramedic abilities.

Eggers et al. [13] cover the difficulties faced by paramedic education programs in providing efficient training in technical medical and emergency management capabilities. Traditional lecture-based education techniques frequently do not provide the opportunity for trainees to see how their decisions affect patient outcomes, or to practice skills automatically. The paper focuses on the necessity of using cutting-edge instructional design techniques to produce more complex and realistic paramedic training programs. The authors advise the use of technology, such as augmented mannequins, to enhance the realism and specificity of simulations.

The use of machine learning in paramedicine is examined by Strum et al. [14] In light of the huge paramedic data repositories that are accessible in Canada, the authors highlight the potential advantages of machine learning in paramedic clinical decision-making. They propose that, for complicated patient presentations, machine learning algorithms might help to determine point-of-care therapy and the best destinations for patient transfer. The article also underlines the significance of combining paramedic and hospital ED data in order to evaluate the efficacy of prediction models. It is suggested that paramedic services, data scientists, and data centres work together to overcome obstacles and harness the full potential of machine learning in paramedicine.

Honda et al. [15] focus on the use of AI to create a standardised instructional system for paramedics who specialise in treating elderly dementia patients. The study used a training regimen that included lectures, seminars, and training in rescue simulation, and an AI system was created to evaluate face-to-face interaction, including shared eye contact, reciprocal gaze, and other components. The findings indicated a significant improvement in paramedics' interactive communication abilities. Despite no discernible difference in empathy ratings, participants felt that the training was useful for their everyday job.

These articles offer insights into a variety of paramedic training and education-related topics, with the overall focus on how to build skills, make decisions, and communicate by integrating AR/MR, simulation methods, VR technologies, machine learning, and AI more effectively. The findings underscore the need for further study to improve paramedic training and practice while highlighting the possible advantages and obstacles associated with these technologies.

IV. DISCUSSION

This review offers a comprehensive overview of the application of artificial intelligence (AI) and related technologies in paramedic education, with a specific focus on augmented reality (AR), virtual reality (VR), mixed reality (MR), simulation, and machine learning. One of the reviews included in this study found insufficient evidence to support the notion that augmented and mixed reality (AR/MR) can produce results comparable to or superior to conventional simulations in paramedic education.[7] Conversely, another study examined simulation practices in paramedic education and concluded that simulation is a crucial teaching method that enhances students' competency and clinical skills.[11] This study outlined numerous ideas presented in the literature, providing a comprehensive understanding of the use of simulation.

ParaVR, a virtual reality training simulator for maintaining paramedic abilities, was developed through four phases: defining needs, alpha development, beta development, and project management.[12] The project, which uses 3D modelling software, the Novint Falcon haptic device, and the Oculus Rift head-mounted display, highlights the potential of VR for improving the development and maintenance of paramedic skills in rare procedures such as needle cricothyrotomy and needle thoracostomy. Rees et al. address a critical research gap by providing empirical evidence for the effectiveness of VR in paramedic training, which was lacking in previous studies. [16]

The paper by Eggers et al. [13] explored the challenges faced by paramedic programs in the USA, focusing on lecture-driven training approaches. It emphasises the need for instructional designers to adopt design thinking and technologically-enhanced mannequins for teaching recovery skills but acknowledges their limitations in simulating complex and realistic scenarios. The drawbacks of conventional lecture-driven teaching strategies in paramedic programs were also highlighted. This is consistent with other research that has pointed out the drawbacks and difficulties of lecture-based methods in paramedic education. [17,18]

Strum et al. [14] proposed a practical framework for machine learning in paramedicine, focusing on improving clinical decisions and point-of-care interventions. They highlighted the importance of combining hospital ED and paramedic data for accurate forecasting of patient outcomes, and suggest that collaboration between data scientists and paramedic services could remove obstacles and create new care models for non-emergent ailments and patient re-routing. The authors' suggestion for using machine learning in paramedicine is consistent with other research that found machine learning algorithms have the potential to enhance paramedic clinical decision-making. However, the particular emphasis on fusing hospital ED and paramedic data to create precise prediction models constitutes a fresh strategy. [19]

The project by Honda et al. [15] aimed to develop a uniform training program for dementia care paramedics in Japan. Participants took part in lectures, workshops, and rescue simulations. AI was then used to assess their communication abilities, and it was found that the training had significantly improved their interactive communication. Participants expressed satisfaction with the application of this AI-based approach in their daily jobs. This project is unusual in that it applies AI to create a standardised teaching program for paramedics specialising in dementia care: no prior research has thoroughly investigated the application of AI in paramedic training specifically with regard to dementia-related communication skills.[20,21]

Overall, the studies provide new insights into the application of AR/MR, VR, machine learning, and AI in paramedic education and training. They expand upon previous research by exploring innovative approaches and addressing specific challenges faced by paramedics in their practice.

Advantages of Applying AI in Paramedic Education [22]:

AI can improve learning experiences, information retention, and student engagement by tailoring the experience to individual needs. Simulation and VR platforms can provide paramedics with realistic settings, bridging the gap between theoretical knowledge and implementation. Intelligent tutoring systems can provide immediate feedback and direction, identifying problems and providing personalised help. Data analysis and predictive models can help to identify patterns, trends, and areas for development, enabling early detection of medical crises, optimisation of resource allocation, and enhanced emergency response.

Nonetheless, ethical concerns, technological challenges, and lack of human interaction are essential considerations for the proper and equitable use of AI in paramedic education. One potential drawback is the overreliance on AI, which may diminish the significance of human-to-human interaction in the learning process. Balancing technological advancements with human-centred values is essential to ensure that AI enhances, rather than detracts from, the quality and equity of paramedic education. This requires careful consideration of ethical concerns, technological challenges, and the potential limitations of AI-driven learning compared to human-to-human interaction. Addressing algorithmic prejudice, data privacy, and the possibility of AI replacing human teachers is crucial. AI cannot replace mentoring and human connection, and some topics, like interpersonal abilities and emotional intelligence, may require in-person instruction. Integrating new systems and ensuring compatibility are further challenges. Continuous adaptation, requiring research, development and training, is necessary to keep up with the rapid evolution of AI technology.

Ethical guidelines should be established for AI's application in paramedic education, taking into account concerns such as data privacy, algorithmic bias, and human supervision. A collaborative approach should be encouraged between paramedics, educators, and AI specialists to ensure that AI technologies meet the unique requirements of this field. Training and assistance should be provided to ensure that paramedics and educators are skilled in the deployment of AI technology, fostering a culture of continuous learning, technical training, and

recognition of AI's constraints.

AI-enabled paramedic education can improve emergency response by equipping paramedics with the latest information and skills, leading to more efficient response and improved patient outcomes. AI algorithms can analyse data from training and real-life situations to identify areas for improvement, thus enhancing training plans and curriculum creation. Standardised training and evaluation procedures can ensure uniform quality across educational institutions and regions, promoting international norms and professionalisation of paramedic staff. Furthermore, the incorporation of AI into paramedic training offers research opportunities in the areas of customised learning, adaptive learning environments, human-AI interaction, and emergency response outcomes, improving evidence-based practice in paramedicine.

V. CONCLUSION

The incorporation of AI into computer systems allows them to carry out activities that would ordinarily require human intellect. This has the potential to fundamentally alter how students learn, the kind of education they receive, and the efficiency with which healthcare is delivered as a whole. When it comes to customised learning, whereby students might receive training and materials specifically suited to their requirements, skills, and shortcomings, AI can have a significant influence. Using virtual reality (VR) and augmented reality (AR) technologies, which can create immersive training environments where students can practice clinical procedures, emergency response scenarios, and patient interactions, AI can also improve the simulation and training aspects of paramedic education. Thus, AI can help students feel more competent, confident, and capable, resulting in better patient care outcomes.

AI systems can analyse vast volumes of data to identify patterns, connections, and insights that humans might overlook. AI-driven solutions that enable clinical decision-making, data analysis, and information retrieval might also be useful to paramedic students. Nonetheless, the incorporation of AI into paramedic education is not without its difficulties and ethical dilemmas. These include the necessity for human control and responsibility, bias in AI systems, and the privacy and security of patient data.

AI has the potential to completely change how healthcare is provided and how paramedic students are taught. We can harness this potential in the future by embracing these technological developments and resolving the associated ethical issues.

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