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Literature review

A scoping review of metaverse in emergency medicine

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A B S T R A C T

Background: Interest in the metaverse has been growing worldwide as the virtual environment provides opportunities for highly immersive and interactive experiences. Metaverse has gradually gained acceptance in the medical field with the advancement of technologies such as big data, the Internet of Things, and 5 G mobile networks. The demand for and development of metaverse are different in diverse subspecialties owing to patients with varying degrees of clinical disease. Hence, we aim to explore the application of metaverse in acute medicine by reviewing published studies and the clinical management of patients.
Method: Our review examined the published articles about the concept of metaverse roadmap, and four additional domains were extracted: education, prehospital and disaster medicine, diagnosis and treatment application, and administrative affairs.
Results: Augmented reality (AR) and virtual reality (VR) integration have broad applications in education and clinical training. VR-related studies surpassed AR-related studies in the emergency medicine field. The metaverse roadmap revealed that lifelogging and mirror world are still developing fields of the metaverse.
Conclusion: Our findings provide insight into the features, application, development, and potential of a metaverse in emergency medicine. This study will enable emergency care systems to be better equipped to face future challenges.

Contents

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Introduction

The term “metaverse” was coined in 1992 by Neal Stephenson in the science fiction novel *Snow Crash.* It consists of the prefix “meta,” meaning “transcendence and virtuality,” and the stem “verse,” meaning “world and universe.” Metaverses are immersive, collaborative environments that are three-dimensional and real-time virtual worlds where multiple users conduct social, economic, and cultural activities and interact with each other through avatars and their environment without any physical separation [1,2]. Although the metaverse was introduced 30 years ago, there has been limited improvement in it. This is because of the technical challenges in the processes of communication, shared understanding, and coordination [2].

Many industries have adapted to the metaverse phenomenon, including the healthcare industry in 2021. In health industries, several trends in technological developments, such as artificial intelligence, machine learning, blockchain, and personal big data, enhanced the role of digital assistants' ubiquitous distribution [3]. The growing role of a metaverse in several fields because of the emergence of technical improvements such as the brain-computer interface has fostered capabilities that support interpersonal relationships and improve the execution of virtual projects.

To monitor the emerging trend of the metaverse and understand its potential application in the future, we aim to evaluate its applicability in the emergency medicine field. However, there has been little research and information on the metaverse. Only 40 results were retrieved from the PubMed database in May 2022 when the search term “Metaverse” was entered. Hence, to our knowledge, we conducted a scoping review, the first report of a metaverse in emergency medicine. The scoping review of current studies is essential, considering the potential impact of the metaverse on the future healthcare system. We explored information from the metaverse roadmap relating to the basic concepts of four types of metaverse: augmented reality (AR), lifelogging, mirror world, and virtual reality (VR), aiming to assess the status and applications of these technologies in emergency medicine.

Materials and methods

The Acceleration Studies Foundation created the metaverse roadmap using two dimensions to explain the four types of the metaverse [4]. We kept the classification and modified the axes with previous studies to examine metaverse in the context of emergency medicine [5] (Fig. 1).

There are three axes with the four types of the metaverse. The first axis is augmentation versus simulation. Augmentation technology enhances human sensing or adds new functions to a real-world environment through stimuli. In contrast, simulation technology imitates the world to provide a unique environment by modeling reality. The second axis is intimate versus external. The intimate metaverse focuses on personal behavior and individual data. Thus, the external metaverse focuses on the surrounding world, and the external reality is centered on the user [6]. The last axes are real and virtual worlds, the opposite ends of a continuum. The real and virtual worlds focus on the environment, consisting solely of real and virtual objects [5]. AR is real-world augmentation achieved by integrating real and virtual worlds into a single unified reality, whereas VR creates a simulated environment entirely distinct from normal reality.

Goal and research questions

To ensure that a substantial range of literature was captured relating to the topic of interest, we posed the following initial research questions to guide the search:

(1) What areas have been addressed in current applications of metaverse technology in the emergency health care domain?
(2) What techniques of metaverse are most used in the emergency health care system?
(3) What are the current conditions and reasons for using metaverse techniques in the emergency health care system?
(4) What is the potential for metaverse development in the emergency health care system?

Research protocol

A scoping review was considered to get insight into metaverse's current development and application in emergency medicine. This review is reported according to the Preferred Reporting for Systematic Reviews and Meta-Analysis Extension for Scoping Reviews guidelines with the PRISMA-ScR checklist [7]. The registration number of the review protocol is INPLASY202250159.

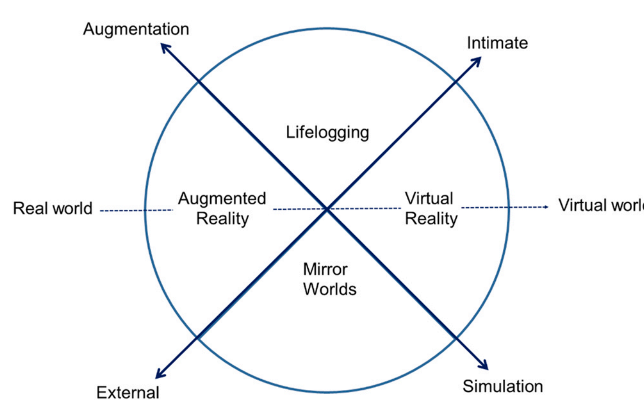

Fig. 1. The four types of the metaverse (Modified from Paul, 1995[5] and John, 2007[4]).

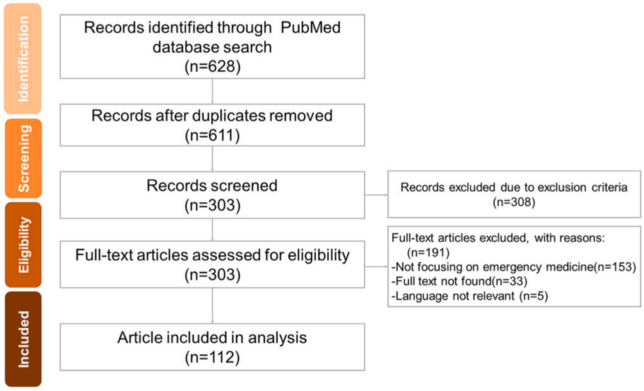

Fig. 2. PRISMA-ScR flow diagram.

Eligibility criteria

To be included in the review, papers were required to report on aspects of metaverse technology as applied to fields of acute medicine. Papers were included if they were published in journals or conference proceedings, including reviews or position papers, irrespective of the maturity level of each published work. Papers were excluded if they did not fit into the study's conceptual framework or if they reported on metaverse technology in the context of an application not directly related to health care.

Information sources and search strategy

We performed our PubMed search on January 15, 2022, using AR, VR, emergency medicine, lifelogging, and mirror world, separately. The search terms were as follows: 1. (Augmented Reality) AND (Emergency medicine), 2. (Virtual Reality) AND (Emergency Medicine), 3. (Lifelogging), and 4. (Mirror world). The final search results were exported into EndNote, and duplicates were removed.

Selection of sources

The authors independently screened the titles and abstracts of all publications and excluded publications with no abstract, no full texts, and no English delivery, as well as publications not related to metaverse or the emergency medicine domain. Subsequently, the two reviewers studied the texts independently and in detail to determine whether they met one of the following criteria of research focus: (1) metaverse in emergency medicine; (2) AR in emergency medicine; (3) VR in emergency medicine; (4) lifelogging in emergency medicine; and (5) mirror world in emergency medicine. Articles not focusing on emergency medicine were excluded (Fig. 2).

Data charting

Two reviewers examined the retrieved articles and recorded information using a predetermined form that two reviewers jointly developed to determine which variables to extract. The following data items were extracted: study type, published time, technology type, and application in emergency medicine.

Since we did not manage to identify scoping reviews on the same topics as the research questions, we opted for a topic-specific alternative for the classification of papers. Through the content analysis process, a concept and its application were identified and used to construct a classification scheme. In the process, data items representing categories were merged or renamed through discussions. Finally, the following four additional classifications were extracted: education, prehospital and disaster medicine, diagnosis and treatment application and administrative affairs.

Synthesis of results

We analyzed the overall results of existing literature regarding the metaverse in the emergency medicine domain. The Sankey diagram depicts the amount of research and relationships. Then, we summarize and discuss the findings for each metaverse concept. Finally, we provide insight into the potential of the metaverse for each of the identified areas.

Results

A total of 628 articles were identified and categorized as AR (N = 297), VR (N = 242), lifelogging (N = 80), and mirror world (N = 9). Then, 628 articles were reviewed according to the inclusion and exclusion criteria, and 112 remained. Among these selected items, the most common article types were pilot studies (n = 44), followed by random randomized controlled trials (n = 25), proof of concept studies (n = 14), review articles (n = 12), metanalyses (n = 1), experimental studies, conferences, and others. (n = 16).

Finally, four thematic categories were identified by two reviewers: education (N = 55), prehospital and disaster medicine (N = 27), diagnosis and treatment application (N = 25), and administrative affairs (N = 5). The four types of metaverse, in descending order, are VR (N = 75); AR (N = 32), mirror world (N = 3), and lifelogging (N = 2). Our review of 75 articles about VR revealed the wide application of VR in education (N = 36), followed by prehospital and disaster medicine (N = 18), diagnosis and treatment application (N = 17), and administrative affairs (N = 4). Our review shows that VR simulators are available in various sizes and shapes, and Oculus Quest is the most used. Further, a review of 32 articles on AR revealed wide application in education (N = 18), followed by prehospital and disaster medicine (N = 8) and diagnosis and treatment (N = 6). Most of the studies used Google Glass and Microsoft HoloLens.

The Sankey diagram revealed the flow between metaverse technology and the four identified thematic categories (Fig. 3). Finally, the result of the metaverse roadmap demonstrated that education is the main classification of applications for the metaverse. AR and VR are the main application technologies, with research on VR-related studies surpassing AR-related studies in emergency medicine. Lifelogging and mirror world are still developing fields of metaverse (Fig. 4).

In this extracted education classification, learning procedural skills with AR includes central line insertion [8], airway management, and ultrasound learning simulation [9]. The concept of AR ultrasound simulator, which uses contextual in situ visualization of ultrasound slices simulated from computed tomography, is utilized for clinical training and simulation [9]. AR is also being increasingly applied and studied in resuscitation training programs. These programs provide high-quality chest compression using the AR cardiopulmonary resuscitation (CPR) training system [10], CPR refresher training course [11], and pediatric septic shock simulations [12]. Also, VR plays a role in intubation [13,14] and surgical airway training, obstetric forceps delivery, and ultrasound. In ultrasonographic training, VR can support learners in developing spatial relationships and realistic anatomical structures through immersive and interactive experiences [15]. Conventional CPR training has limitations because it lacks realism and immersion. VR is one solution that establishes a virtual educational environment and provides trainees with a sense of realism that has already been used in CPR training [16]. Furthermore, it is a potentially powerful tool for fostering and improving bystander intervention. It includes calling the emergency services (911 or other local emergency numbers) and asking for an automated external defibrillator for sudden cardiac arrests [17,18]. In critical care education, VR-based training in diabetic ketoacidosis and status epilepticus has boosted the confidence

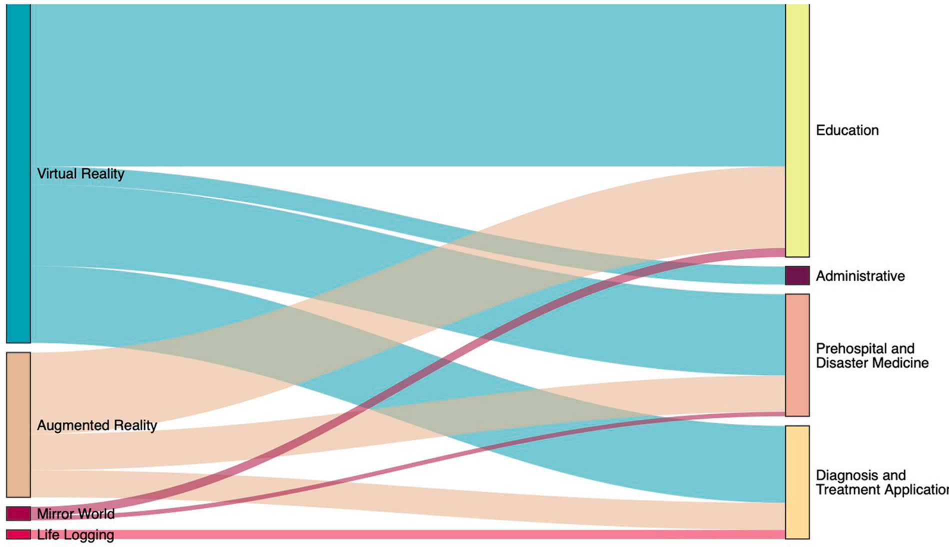

Fig. 3. The Sankey diagram, with cluster order by size, revealed four types of the metaverse in four thematic categories.

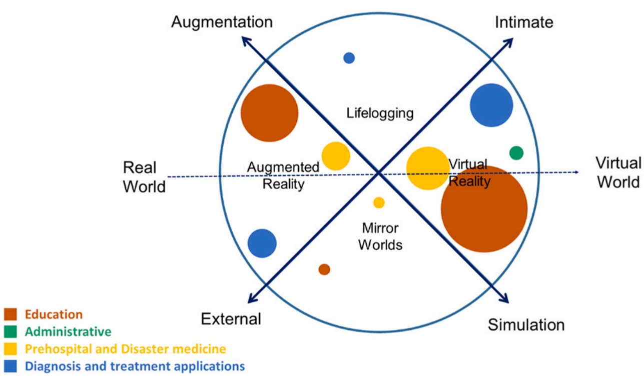

Fig. 4. Metaverse roadmap with thematic categories in current emergency medicine.

of those managing critical patients and facilitate positive changes in their practices [19,20]. Also, VR has played a crucial role in COVID-19-related skill training that includes collecting nasopharyngeal swabs and donning/doffing personal protective equipment and is considered a helpful tool for acquiring simple and complex clinical skills in Japan [21].

In this classification of diagnosis and treatment application, the number of studies in VR exceeded AR. However, AR can provide medical support to emergency physicians in daily operations, e.g., to overcome the challenge of rare events in a pediatric emergency, an assistance service with an integrated AR emergency ruler was applied for size measurement and calculation of dosages of drugs such as amiodarone [22]. AR also has a vital role in trauma evaluation and management. Brain concussion assessment through accelerometry measurements obtained from the head with the help of smart glasses provided an objective assessment of concussion symptoms [23]. In the case of a difference of opinion between patient and health provider goals regarding information and education for specific diseases, AR can be used to explain each piece of information and the relevant treatment plan so that the patient understands. Mixed reality is used in patients with myocardial infarction to ensure optimized knowledge transfer that enhances medication adherence and improves recovery [24].

Regarding VR application, 16 out of 17 studies focused on pain control, including 14 on children and two on adults. The remaining study was a randomized controlled pilot study that used VR for posttraumatic stress disorder symptoms following a traumatic event in the emergency department, which revealed no significant difference between the intervention and control groups [25].

Only four articles categorized under administrative affairs were identified. One example related to the evaluation of emergency medicine applicants; VR, as an interview technique, allowed interviewers to gain insight beyond the traditional paperwork and face-to-face interaction [49]. Another example was the development of a virtual emergency department to get insights into strategies for managing patient flow [26].

Discussion

This section discusses the four types of the metaverse and their development.

AR and VR

AR is a real-time interactive experience of a real-world environment through digitally generated three-dimensional representations integrated into real-world stimuli and existing reality [4]. It features the fusion of real and virtual worlds into a single, immersive, and unified reality. Google Glass and Microsoft HoloLens are the instruments most commonly used. Google Glass focuses on technology that runs on almost all smartphones. Still, the HoloLens is moving toward depth sensing that can recognize and interact with the environment and recognize human gestures, the latest trend in AR [22]. VR is an interactive three-dimensional computer that generates a simulated environment, completely segregated from normal reality, where people can interact using special equipment. It provides an immersive, interactive experience for users similar to their daily life experience, and this realization of presence has potential for application in the healthcare system.

AR and VR in education

The learning ways are changing with the rapid development of new technologies. The focus is on providing efficient and quick access to high-quality knowledge. Several studies have shown the potential of AR in bridging the gap between achieving skills required in the real-world, high-pressure environment and training in a virtual environment, which enables time- and cost-effective independent learning and increases learner engagement [28]. However, there is still a lack of studies and evidence about evaluating learning performance, integrating augmented reality with independent learning, and assessing the effectiveness of traditional methods [29].

VR technology is used in many medical specialties, including emergency medical education training for various tasks and collaborations. The virtual environment allows various life-threatening clinical scenarios and cases to be repeated in a safe, reproducible, immersive, and interactive setting. In emergency medicine, learning procedural skills is vital, as is performing routine CPR simulation, and perfecting clinical management is very important. Therefore, high-fidelity, simulation-based education and assessment are increasing in emergency medicine. Studies revealed its advantage in overcoming the limitations of practical education, which has a positive effect on learner satisfaction and learning ability [30]. In the future, further research can identify relevant applications, best practices, and optimal technologies and help evaluate performance, allowing greater focus on the acceptance of technology and the establishment and integration of training systems [31,32].

AR and VR in prehospital and disaster medicine

AR and smart glasses have proven to offer useful techniques in disaster medicine [33]. The application of smart glasses in triage during a mass casualty incident led to digital capture of the triage results, which provided tactical advantages compared to conventional approaches and even supported the decision-making and speed up processes [33,34]. Furthermore, it improves the operators' performance and helps them make better choices. [35] Similarly, VR technology is applied in many fields in disaster medicine, including education, professional training, mental health, etc [36,37]. VR-simulated environments help medical providers regularly respond to often chaotic settings such as high-acuity and low-frequency disasters rather than have their skills atrophy from the rarity of such events [38]. Triage skills training is studied the most. In some studies, the VR method of teaching, learning, and testing the abilities for assessing mass casualty triage was found to be as efficient as clinical simulation [39–41]. It is also needed in prehospital use to evaluate the quality of CPR. The driving patterns compiled during ambulance transport revealed that compression depth was shallower in speed bumps and sudden-stop sections, although further clinical significance remains to be determined [42]. Disaster medicine training usually includes large-scale, real-life exercises, which are resource-intensive and expensive. VR seems to have more advantages than AR, which not only creates highly realistic, instant feedback within an interactive setting but also reduces cost and provides a stable and reproducible scenario [37].

AR and VR in diagnosis and treatment application

AR can provide medical support to emergency physicians in their daily operations. Although there is a great variety of studies, most are still in the early stages of research, while some do not apply to real-time patient management. However, it is apparent that in the future, the range of applications in this field may be more comprehensive when compared to VR. In contrast, VR enables users to feel immersed, similar to how they feel in daily life situations. This sense of presence has a variety of potential applications that include improving mood, overcoming situational anxiety, and increasing pain tolerance [43]. Therefore, VR interventions have been used the most in treating neuropsychiatric disorders such as schizophrenia and autism [44]. In this classification, VR seems to have more research than AR, but the variety is limited. Pediatric pain and its management are challenging for the workforce in the emergency department. VR has been studied and identified as an effective and adequate tool that can significantly reduce the fear of pain, whether needle-related procedural pain, laceration repair pain, or other, as well as anger and anxiety levels [45–49]. VR application is rare in this thematic category, which may be due to the features of the technology. Further research may focus on different applications, not only pain relief in various etiologies. Virtual reality education programs for specific diseases seem possible. VR may be applied as a tool to better prepare patients for disease knowledge, medical procedures, and health education through the development of VR videos, which are effective in reducing anxiety, and stress and increasing the efficiency of doctor-patient communication [50].

AR and VR in administrative affairs

This thematic category focused on administrative affairs, such as managing costs and the workforce. No AR articles were identified related to the application of administrative affairs. However, applying VR to gain insights into strategies for managing patient flow was seen as a great opportunity; a virtual emergency department was developed, comprising a hybrid simulation that combined a virtual environment, technical skills simulation, simulated patients, and caregivers. It seemed realistic, with no significant difference from the real world. The users were represented as characters called avatars that interacted with each other and the environment. The model explored effective factors, quality of care, and patient safety in overcrowding [26]. This model was close to the metaverse since the virtual scenario of the emergency room was the same as the real world, called the mirror world.

Mirror world

The mirror world is the depiction of the real world in digital form [51]. It is a simulation of the external world that offers accurate real-world structures and human environments transferred to VR as if reflected in a mirror [51]. Microsoft Virtual Earth and Google Earth are examples of mirror worlds.

Our review has few applications of the mirror world in emergency medicine. Alina et al. demonstrated that it was effective for teaching emergency medicine using 360-degree video during the COVID-19 pandemic [52]. Immersive videos are recorded using omnidirectional cameras that help students learn the basics of emergency care. These 360-degree video scenarios try to emulate the on-site training sessions to overcome the rule of social distance during the COVID-19 period [52]. This concept is identical to the metaverse, with scenarios similar to the real environment and avatars (created digital representations controlled by users) that can interact with each other. The technique also lets students experience surgical procedures as if they were present in the operation room without time restriction [51]. With the technology features and current development of the mirror world, two classifications, specifically education and prehospital and disaster medicine, may have more potential in the coming years. However, the practical application and research of the mirror world are still limited, and there is still a gap in making such dreams come true.

Lifelogging

Lifelogging is a technology that acquires the digital record of an individual's personal experiences by capturing, storing, and sharing multimodally through digital sensors [53]. It is considered similar to an automated biography that offers information and knowledge about how we live our lives. With the convergence of technologies, advancements in sensing technology, and reduction of costs, the emergence of lifelogging has become a mainstream activity. Wearable sensors and devices are the concepts of lifelogging used to trace life activities better to understand human physical condition and performance in daily life [54]. Personal collection of one's health information, including health-related daily activities, dietary records, daily step counts, blood pressure, and body weight, via recording through a wearable device and mobile apps is successful in improving lifestyle behavior [55]. The continuous or discontinuous biological signals such as electrocardiogram and electroencephalogram, recorded by wearable devices, reveal vital information about the patient's health. They provide necessary assistance in times of ominous need, which is crucial for diagnosis and treatment [56]. Patient-generated health data are essential for clinicians to manage chronic and acute diseases and engage patients more rapidly and actively. One example is its combination with the Internet of Things (IoT) technique that enables wireless, interrelated, and timely health data and information to provide medical care with precision [57].

Thus far, lifelogging is mostly used to control chronic diseases that occur daily and helps improve the quality of life. It has a wide application in emergency care once the healthcare system allows the connection to and transfer of personal data (through IoT). After overcoming the technological challenges, it may promptly provide clinical data such as compliance related to medicine, initial heart attack rhythms, and patterns and scenarios of syncope or seizure attacks to the emergency physician. With the technology features and current development of lifelogging, diagnosis and treatment application classification may have more potential in the coming year. However, the privacy risks and security considerations about personal data are concerning. Further study of privacy risks protection, data encryption, and data storage would benefit the ongoing development of lifelogging technology.

Potential of the metaverse in the four extracted thematic categories in emergency medicine

Combined with current reviews and technological features of the metaverse, we try to draw a picture of a potential metaverse in acute care medicine (Fig. 5).

Education

Education is the main field of application for both AR and VR. Emergency medicine is an early adopter of technology-based education tools, because of the need for skills and ability to adapt to a variety of emergent clinical scenarios [57,58]. AR and VR integration into clinical training may be an effective educational strategy that enhances skills and knowledge learning and improves the experience in a simulated environment. Therefore, the trend of the metaverse in emergency medicine education, especially resuscitation, will be carried forward because of its applicability in teamwork learning, decision-making, and high-stress immersion resuscitation experience. We believe that the application of AR and VR in education will continue to grow, and the latter has more potential because

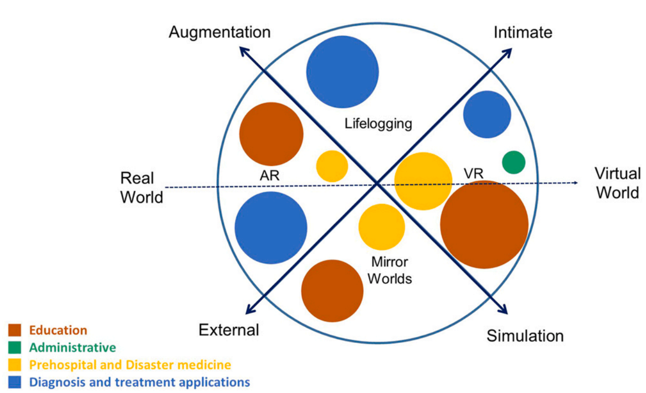

Fig. 5. Potential of the metaverse in emergency medicine.

it reduces the need for real-world stimuli. Furthermore, the concept of the mirror world is also being explored, and it may emerge as popular once the cost and technique are finalized. By actively utilizing the characteristics of the metaverse, a higher degree of freedom and a greater variety of environments will be provided for creating, sharing, and learning, not only for students but also for teachers.

So far, its effectiveness compared with traditional educational methods is still equivocal in some studies, and further research with a larger sample size needs to be conducted to understand the feasibility and effectiveness of such a curriculum [59]. Furthermore, future studies can attempt to characterize the best uses for AR/VR, analyze the positive and negative effects on students' learning activities, and incorporate the findings into conventional medical, and educational methods in a better way. Moreover, emergency physicians and emergency medicine societies should become more involved in metaverse technology development and assessment, promoting simulation platforms across specialties through interdisciplinary and multi-team collaboration [60].

Prehospital and disaster medicine

The number of prehospital and disaster medicine studies plays a crucial role in our review. Disasters are an inevitable truth of our life, prompting us to be prepared for the future. The immersive, low-cost, and replicable features of VR technology will better equip the healthcare system to withstand disastrous impacts in the future. Triage skills training is studied both in AR and VR. Gradually, health providers are focusing on training for optimized decision-making and action-taking during mass casualty incidents [61,62]. The advancement of technology in the mirror world will have vast potential as the virtual world is synonymous with the daily environment and will be helpful for disaster simulation and preparation. However, most simulation training systems still have deficiencies in their application experience. The most common barriers are efficacy evaluation and privacy concerns. The lack of evaluation functions means an inability to determine the level of skill acquisition, and corresponding privacy protection research is urgently needed to reduce privacy leakage [63].

Diagnosis and treatment application

This extracted thematic category in emergency medicine has fewer applications than other subspecialties. However, this classification's applications will greatly increase, especially in AR and lifelogging, once the technology advances. There has been diverse research on emerging concepts and applications of AR that are novel; however, most are pilot studies and need to be explored further. VR interventions are emerging as promising tools in acute pain management, especially in pediatrics [46,64]. VR will be a potential tool for information transfer and communication about disease knowledge, medical processes, and health concept education in emergency care practice. Thus, we may assume that AR has more potential and applied value in the future because of its capability to integrate with real-world stimuli and existing reality in clinical practice. So far, the effect in clinical management is still limited, but some techniques seem to benefit physicians, although more application and evidence are needed in the future.

The healthcare lifelogs can efficiently explore valuable results from big data as they collect real-time data of various types from individuals. Still, health providers in acute care do not yet seem to benefit [65,66]. Much research has been conducted in recent years to discover different lifelogging attributes, but most current surveys are not very comprehensive, being limited to a single aspect. There is significant potential for lifelogging to be used within healthcare to enhance current practices [67]. It can provide clinical data, such as medical compliance, the rhythm of heart attack, and pattern and scenario of syncope or cerebrovascular accident, via its wearable devices once the technological challenges are overcome. With the growing trend to broadly adopt wearable devices and the rapid progression of IoT and big data science, lifelogging will soon play an essential role in clinical practice for acute medical care.

In the foreseeable future, healthcare systems will capture, analyze, and store personal data in some external gimmick, which may raise ethical and legal questions [3]. Privacy is still a top concern since the user's loss of autonomy and data might result in individuals being taken advantage of by commercial entities and governmental agencies. In future research, it will be necessary to explore clinical relevance and evidence, especially regarding privacy [65]. It would also be advisable to expand the study of such devices to consider acceptability among people who are not acutely ill, including those with systemic risks such as heart disease and hypertension.

Administrative affairs

Metaverse opens many possibilities by providing a space for modern social communication, fresh experiences with high immersion, and a high degree of freedom to work and create [26,27]. Therefore, work performance, process improvement, resource application, and workforce management are related issues in all industries, including healthcare. Long-term issues with overcrowded emergency departments may be solved via VR simulation and adjustment. With the development of the metaverse, more solutions will be forthcoming. For metaverse to be effective, implementing technology-driven applications will require organizations to develop, support, and iterate clinician, nurse, technology team, and system workflows for continued acute healthcare improvements [2].

Limitation

In this study, we conducted a scoping review to investigate the potential impacts of the metaverse in emergency medicine. However, regarding the practical application of metaverse, the technology still has identifiable limitations and deficiencies in system equipment, clinical implementation, evaluation functions, etc. Therefore, the current application range is not very broad, and related studies are rare. Although most healthcare providers and researchers have high expectations, significant challenges face the large-scale adoption of the metaverse. This is because of various limitations regarding technical skills, cost, and regulatory and privacy concerns.

We collated current research and attempted to explore a potential paradigm shift in the future emergency care system. However, the methodological choices led to limitations in the research process, including the use of search string and query extracted evidence from a single database and a focus on emergency medicine, which cannot elucidate all the features of the metaverse. Most studies are pilot studies or randomized controlled studies that need more evidence. While many studies shared some commonalities, most were still unique in their own ways, making them challenging to compare. The four types of extracted classifications may overlap in some details and concepts. Publication bias may be present because of the recording and sharing of administrative applications that are difficult to digitize.

Conclusion

Metaverse in emergency medicine creates a variety of opportunities by fostering near real-time experience in emergency medicine by providing highly immersive experiences in clinical training and education, prehospital and disaster medicine, diagnosis and treatment application, and administrative affairs. AR and VR are the main application technologies in the metaverse and are used the most in the education field. VR-related studies surpass AR-related studies in emergency medicine, but AR holds greater potential in the classification of diagnosis and treatment application. Lifelogging and mirror world have fewer applications but will stimulate emergency medicine once the techniques are developed. Lifelogging will provide more personal information to health providers, and the mirror world promises to be a powerful tool for training in disaster medicine response.

Metaverse brings a new world and various opportunities, but limitations and stumbling blocks exist. This scoping review will provide the emergency care systems with adequate preparedness to face future challenges. Health providers should ensure the ethical use of personal information and pay attention to data privacy protection, security, and governance. A thorough examination of the ethical aspects and applications of metaverse will prove beneficial for future responsible development of this field.

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Not applicable.

Consent for publication

Not applicable.

Author contributions

TCW drafted the manuscript. TCW, CTBH revised it critically for important intellectual content. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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