Review Article

Role of augmented reality and virtual reality from the Indian healthcare education perspective – A systematic review

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Abstract

Augmented reality (AR) and virtual reality (VR), are upcoming technologies with considerable potential to revolutionizing healthcare education, enhancing patient safety, and improving healthcare quality particularly in the Indian context. This review is conducted to view the current scenario of Indian context considering the impact of COVID-19. The current systematic review study was done following PRISMA 2020 guidelines using the key terms "Augmented Reality," "Virtual Reality," "Healthcare," and "India." Only the PubMed database was selected based on its reputation and authenticity, which is the only limitation of this study and strength. Both qualitative and quantitative methods are used for synthesis of results. In Indian context, 12 (1.7%) and 36 (2.2%) articles related to AR and VR were found, respectively. Six abstracts could not be retrieved, and after screening abstracts, three were found not suitable in VR and eight were found duplicate. A total of 30 articles were considered for this review. 18 (50%) were original, 12 (33.3%) were review, and 6 (16.7%) were other articles. 03 (8.3%), 21 (58.3%), and 12 (33.3%) articles were related to AR, VR, and both AR and VR, respectively. Considering the single database search and six unretrievable abstract, AR, VR, mixed reality (MR), soft e-skin, and extended reality (XR) technologies have the potential to revolutionize healthcare education and training, reducing real-life errors and improving patient safety. Although the Indian healthcare sector only contributes 1.7–2.2% to PubMed publications related to AR and VR.. The review was not registered.

Keywords: Augmented reality, education, extended reality, healthcare, India, mixed reality, soft e-skin, technology, virtual reality

Introduction

Technology is essential for the development and sustainability of healthcare. Newer technologies were developed and incorporated for advancement in patient care like augmented reality (AR), virtual reality (VR), artificial intelligence (AI), machine learning (ML), Internet of Things (IoT), block chain technology, big data, cloud computing, deep learning (DL), neural network, and telemedicine. This current study is limited to AR and VR only.

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Received: 06-03-2024 **Revised:** 01-04-2024
Accepted: 21-04-2024 **Published:** 26-07-2024

Access this article online

Quick Response Code:

Website: http://journals.lww.com/JFMPC

DOI: 10.4103/jfmpc.jfmpc_368_24

AR enhances the natural environment around users by integrating experience with virtual information over physical models and objects, which has improved the understanding of physiological mechanisms and anatomical structures,[1] whereas VR helps the user interact with the virtual environment realistically by providing a three-dimensional (3D) view of the structures inside the body with high-level precision.[1,2] More advanced mixed reality (MR) is an immersive technology that provides virtual content to interact with essential elements.[1,3] The scope of AR, VR, and MR in modern-day medical training and general primary care practice is enormous and impacts the learning environment and offers an opportunity to exchange knowledge and skills among primary care physicians. AK Mahapatra *et al.* (2009)[2] mentioned that the scenario in India is no different from any developing country, but there is considerable progress due to technical advancement,

How to cite this article: Mondal R. Role of augmented reality and virtual reality from the Indian healthcare education perspective – A systematic review. J Family Med Prim Care 2024;13:2841-50.

which is gradually adopting technologies in health science. The COVID-19 pandemic has significantly impacted medical practice and education, leading to the adoption of AR and VR simulations in the industry.[3-6] This shift in education aims to develop the best practices in the academic medical curriculum and primary care physicians.[4,5,7] Simulation-based training improves speed and fluidity in general surgical skills but can cause distortion of patient forces.[5] Several studies on AR and VR are available individually and combined worldwide from various Institutions.[4-12] The current review study explores the application of AR and VR technologies in the Indian Healthcare sector, counting the COVID-19 impact. Use of technology will improve the primary patient care among general physicians.

Methods

The systematic review study is composed following the PRISMA 2020 guideline. The study was designed to find out the research works related to AR and VR involving the Indian healthcare sector only. To find out that, the keywords used for the search were 'Augmented Reality,' 'Virtual Reality,' 'Healthcare,' and 'India.' Only a single PubMed Database was chosen considering its importance, reputation, and indexing for medical field publication. The database was last accessed on January 27, 2024. 'Augmented Reality' and 'Healthcare' were searched to find the number of articles worldwide, and later, 'India' was added to the search to find the research works related to the Indian context. Similarly, 'Virtual Reality' and 'Healthcare' were searched for worldwide, and later, 'India' was added to find the number of publications related to the Indian context. The search results were sorted by most recent only without applying any filters or limits [Table 1]. A total of 545 and 12 articles for AR issues and 2023 and 36 articles for VR issues were found worldwide and Indian context, respectively. Next, while seeking for retrieval of the articles, one article in the AR category and six articles in the VR category were not retrievable with one in common. In the stage of eligibility by scrutinizing the abstract, in the VR group, three articles were excluded due to not being relevant to the context. All 11 AR-related and 30 VR-related articles were screened for duplication, and eight found common or duplication. Considering both AR and VR, a total of 30 articles were included in the systematic review study for qualitative study [Figure 1]. However, for the quantitative study type and category of articles, a total of 36 including six nonretrievable items were included [Table 2] as we did not have a free full abstract and text available for those six items but had sufficient information for the said quantitative analysis. All the quantitative data were expressed as a percentage.

Results

There were 545 articles worldwide in AR-related and 12 articles in the Indian context. In the VR field in the worldwide healthcare context, 2023 articles were found and 36 articles were found in the Indian context. The search result shows that for AR and VR individually, the Indian context publication numbers represent only 1.7% (12) and 2.2% (36) of the world publications in the PubMed database, respectively [Table 1], and also mentions that the duration of the search varies from 1994 to 2024.

In the Indian context search as per the objective of the study, it was found that in the PubMed database, a total of 36 articles were available in this review for the study. Out of those, total 50% (18) were original articles including three randomized control trials (RCTs), 33.3% (12) were review articles, and 16.7% (6) were other types including one each for short communication, brief communication, brief report, correspondence, and two letters to Editor. Categorywise, articles are AR-related 8.3% (3), VR-related 58.3% (21), and both AR- and VR-related, 33.3% (12). In AR-related publications, 5.6% (2) were original articles and 2.8% (1) were review articles. In VR-related publications, 30.6% (11) were original articles including three RCTs, 13.9% (5) were review articles, and 13.9% (5) were other types. In case of both AR- and VR-related issues, 13.9% (5) were original articles, 16.7% (6) were review articles, and 2.8% (1) were other types of articles [Table 2].

Contributors were found from Indian healthcare organizations in 23 articles (63.8%), from Indian technical organizations in 14 (38.9%), from foreign technical organizations in 13 (36.1%), and from foreign healthcare organizations in 15 (41.7%) articles. Eight articles (22.2%) did not have any contribution from any healthcare organization [Table 3].

There were six articles, no abstracts were available, and only a single database was included in the study.

Discussion

The systematic review with nearly 36 articles found that regarding AR and VR, the Indian healthcare sector is progressing but yet far from the Global stance. Contribution to the PubMed database is only 1.7 to 2.2% of the global publication in PubMed concerning AR and VR. Most of them are original articles (50%) and related to VR (58.3%). Minimal articles were found in the field of AR only. Regarding contributions from different organizations,

Table 1: PubMed database search details with key terminologies

Category of publication	Key terminologies	Publications results	Duration of search	Search time (minute: second)
Worldwide Context	'Augmented Reality' AND 'Healthcare'	545	1997-2024	01:31:04
Indian Context	'Augmented Reality' AND 'Healthcare' AND 'India'	12 (2.2%)	2019-2024	01:22:40
Worldwide Context	'Virtual Reality' AND 'Healthcare'	2023	1994-2024	01:31:57
Indian Context	'Virtual Reality' AND 'Healthcare' AND 'India'	36 (1.7%)	2009-2024	01:27:31

@All Search results are sorted by 'Most Recent' without any other filter.
Last accessed on 27 January 2024

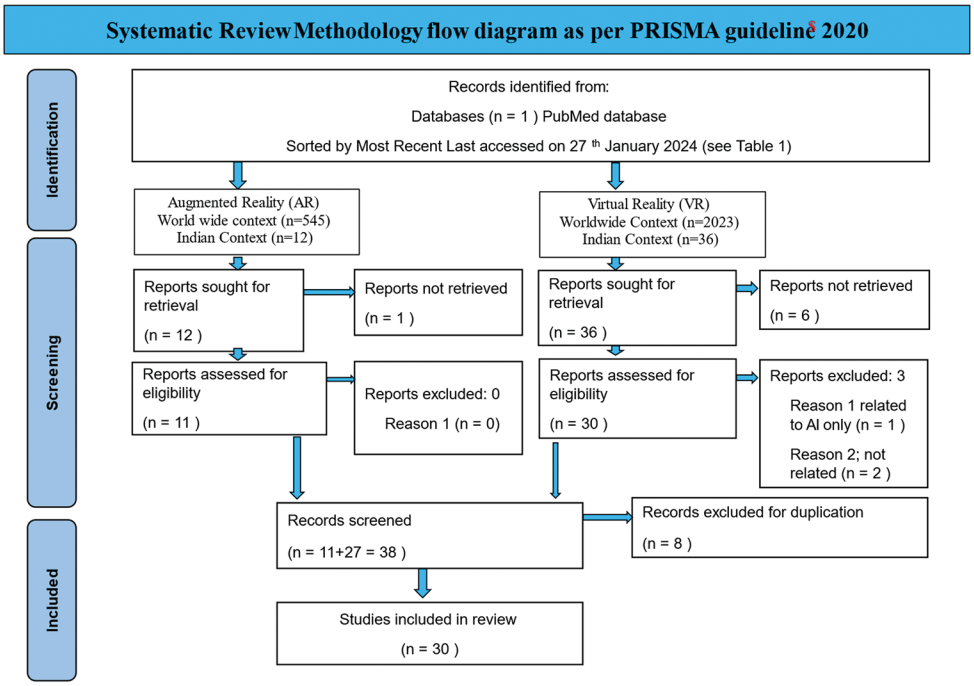

Figure 1: Systematic review methodology PRISMA flow chart

Table 2: Types and categories of contribution details of the articles

Category	Article types available in PubMed			
	Original article	Review article	Others	Total
AR	2 (5.6%)	1 (2.8%)	0 (0%)	3 (8.3%)
VR	11 (30.6%)[1]#	5 (13.9%)[1]	5 (13.9%)[3]	21 (58.3%)
Both AR and VR	5 (13.9%)[1]	6 (16.7%)	1 (2.8%)	12 (33.3%)
Total	18 (50%)	12 (33.3%)	6 (16.7%)	36 (100%)

[x] – 6 number of articles with no free abstract available
- 3 No of articles as RCT

it is noteworthy that there were 22.2% (8) articles where no healthcare was contributed. Isolated contributors of Indian healthcare and technical organizations were 33.3% (12) and 13.8% (5). Collaborative contribution between Indian healthcare and technical organization was 5.6% (2) only. The collaboration between Indian healthcare with foreign healthcare was 25% (9) compared to foreign technical organizations, 11.1% (4).

Both AR and VR have tremendous potency as a new horizon of modality for teaching and training. The unique modality of MR will help the process in the future.

Exceptional works like the use of AR and VR in the urological field have been mentioned by Hameed BMZ *et al.*,[1] and Tharion JG *et al.*[22] studied AR and VR for the sedative and analgesic effects in patients undergoing spinal anesthesia for arthroscopic knee surgery. Lambert V *et al.*[26] included 17 RCTs with 1008 participants aged 4 to 18 and found low-certainty and very low-certainty evidence of the effectiveness of VR distraction in reducing acute pain intensity. Baniña MC *et al.*[30] studied the motor recovery of the upper limb (UL) training in VR applications. They measured how VR programs can deliver high UL exercise intensity and how exercise intensity and difficulty differed among patients and recommended that VR rehabilitation systems be used to provide intensive exercise programs among primary care physicians. Syed-Abdul S *et al.*[32] evaluate the effectiveness of VR among older populations in reducing fall risks and improving social and emotional well-being. The study by Kumar D *et al.*[36] is based on a rehabilitation program for cerebral palsy children using VR-based training (VRBT) and its effect. The author also proposed the vital role of surgical telementoring in the field of surgical training and teaching for general physicians practicing at the primary care level.[38] Medical education utilizes simulation training to enhance skills in a risk-free environment.[37] Utilizing VR, animal models, and simulated patients, simulation training helps students identify strengths and weaknesses, enhancing confidence. Costs range from $100,000 to $300,000 and limited availability of VR simulators are the concern.[4] A few newer technologies like MR, extended reality (XR),[18] soft e-skin,[19] Chat GPT,[11] metaverse,[11,13,17] and NeuroVerse,[13] are showing tremendous improvement in the simulated world.

AR–VR technology found minimal interinstitutional collaboration (within India or abroad) and, specifically, healthcare and technical organizations among the researchers. Also, industrial collaboration with teaching training organizations is hardly visible, which is the need of the hour.[8,9,12,14] Though there are enough pieces of evidence found in Neuroscience,[8,13] Urology,[1] and Rehabilitation[8,18,30,36,37] like specialties application of simulation technologies, Indian Healthcare, as rightly mentioned by Mahapatra AK *et al.*,[2] is still in its infancy to accommodate technologies into the hardcore healthcare practice.

Table 3: Brief description of the articles related to AR and VR

Author & Reference	Type of article		Technology Description			Technological Organization Contribution		Healthcare Organization Contribution		Description of the article (s)
	Original	Review	AR	VR	Others	Indian	Foreign	Indian	Foreign	
Swarnakar R *et al.* 2023[8]	√		√	√	√	-	-	Yes	-	Artificial intelligence and machine learning are revolutionizing rehabilitation medicine by enabling precise movement analysis and adaptive neurorehabilitation. AI-driven telerehabilitation allows remote monitoring and consultation, but healthcare professionals must interpret insights to ensure patient safety as ongoing research determines their effectiveness.
Mehrotra D *et al.* 2023[9]	√		-	√	√	*	*	Yes	-	Intellectual disability affects cognitive, social, and practical domains. A study comparing audio and VR distraction tools on dental anxiety in children found a decrease in pulse, oxygen saturation levels, and Venham's Anxiety Rating, suggesting VR can be beneficial for behavior guidance during restorative dental procedures.
Cardoso SA *et al.* 2023[4]	-	√	√	√	√	-	-	Yes	Yes	Surgical simulation is a vital component of medical education, enhancing surgeons' skills through simulation training using VR. This approach, involving animal models, simulated patients and mannequins, helps students reflect on strengths and weaknesses, enhancing confidence and success before real-life patient encounters. Despite potential issues, simulations offer a cost-effective alternative.
Mahalan N *et al.* 2023[10]	√ (RCT)	-	-	√	√	-	-	Yes	-	Labor pain affects women at both physical and psychological levels, affecting the birth process and delivery outcomes. A study evaluating the effect of audio-visual therapy on labor pain and maternal anxiety found that VR intervention reduced pain intensity and anxiety scores among laboring women compared to standard care. However, no significant difference was noted in maternal vital signs and labor and neonatal outcomes between the groups. Nonpharmacological pain relief methods are gaining popularity among laboring women and healthcare professionals.
Sharma M *et al.* 2023[11]	√	-	√	√	√	Yes	-	-	-	ChatGPT and Metaverse are increasingly used in healthcare training for remote patient monitoring, providing immersive learning experiences. ChatGPT creates simulated patient interactions, while Metaverse provides virtual reality simulations. The unification of these technologies enhances nursing education, improving patient outcomes and care quality.
Lakshminarayanan V *et al.* 2023[12]	-	√	√	√	-	Yes	Yes	Yes	Yes	Intellectual capital is a crucial resource in the healthcare industry, but current systems struggle to adapt to global health records. Edge computing, an emerging trend in IoMT, can balance healthcare resources and achieve healthcare equity. It aids in distributed and collaborative information management, minimizing information exchange with central servers. IEC encourages digital health data processing at the edge, increasing privacy. Afford ableness in digital healthcare is crucial, and combining edge computing with AR/VR can help in remote areas
Kundu M *et al.* 2023[13]	√	-	√	√	√	-	-	Yes	Yes	NeuroVerse, a metaverse application of modern technology, represents a paradigm shift in neurosurgery. Its potential elevates procedures, enhances patient care, and reshapes training. However, challenges like privacy, cybersecurity, ethical concerns, and healthcare inequalities need to

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Author & Reference	Type of article		Technology Description			Technological Organization Contribution		Healthcare Organization Contribution		Description of the article (s)
	Original	Review	AR	VR	Others	Indian	Foreign	Indian	Foreign	
										be addressed. Despite its potential, more research is needed to encourage widespread use of the metaverse in healthcare, focusing on morality and credibility.
Dhar E *et al.* 2023[14]	-	√	-	√	-	Yes	Yes	-	Yes	The COVID-19 pandemic has significantly impacted medical education and clinical care, with VR playing a crucial role. A scoping review of 3743 studies identified 28 studies, focusing on medical education and clinical care. The review found significant improvements in medical education and clinical care, with VR systems being safe, engaging, and beneficial. However, variations in study designs, VR contents, devices, evaluation methods, and treatment periods exist. Future studies should focus on creating definitive guidelines for improving patient care.
Syed Abdul S *et al.* 2022[15]	Brief communication		-	√	-	Yes	Yes	-	Yes	The COVID-19 pandemic has accelerated globalization and digitization of education, including medical training. VR is being embraced for its 3D environment and network resources, transforming the academic medical curriculum. However, challenges persist in adopting VR technologies for medical training, necessitating collaboration between medical institutes and technology industries for education-related VR content and simulations.
Modgil S *et al.* 2022[16]	√	-	√	-	-	Yes	Yes	-	-	This study explores emerging areas and technologies for digital entrepreneurship during Covid-19, focusing on 23 entrepreneurs' views on Covid-19-induced opportunities. Thematic analysis revealed promising propositions in technology, healthcare, entertainment, and e-commerce. Entrepreneurs' experiences with platforms or technologies revealed opportunities in EdTech, FinTech, cybersecurity, and healthcare. The study offers implications for scholars and entrepreneurs, offering future research scope.
Usmani SS *et al.* 2022[17]	-	√	√	√	√	-	-	Yes	Yes	The metaverse, a three-dimensional (3D) Internet, combines VR and physical reality in a digital space. NFTs, such as AR, VR, and MR, have been used in the treatment of mental health disorders for the past decade. However, excessive use of VR and AR can lead to insecurity, anxiety, depression, and behavioral addiction. The metaverse's potential applications in mental health are yet to be explored, with no other review exploring the future of mental health in the metaverse context.
Shaikh TA *et al.* 2022[18]	√	-	√	√	√	Yes	-	-	-	XR solutions are maturing, with potential applications in healthcare. Akili Interactive's EndeavorRx, a video game therapy, has been approved by the FDA for treating ADHD in children. XR-assisted treatments have shown promising results in treating diseases like Alzheimer's, schizophrenia, and stroke rehabilitation. However, the field of XR-assisted patient treatment is still in its infancy. The potential of XR in healthcare is significant, with potential benefits and future aspects in the medical domain.

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Author & Reference	Type of article		Technology Description			Technological Organization Contribution		Healthcare Organization Contribution		Description of the article (s)
	Original	Review	AR	VR	Others	Indian	Foreign	Indian	Foreign	
Roy AC *et al.* 2022[19]	√	-	√	-	-	Yes	-	-	-	Soft electronic skin (soft-e-skin) is crucial in robotics, healthcare, and augmented reality applications. However, challenges like complex fabrication processes, instability, and difficulty in large areas and mass production remain. A 3D-printable large-area electronic skin made of a soft, resilient polymer has been developed, demonstrating excellent long-term stability and consistent performance. The fabrication process is cost-effective and allows for stretching without considering disjoints among sensing nodes.
Hameed BMZ *et al.* 2022[1]	-	√	√	√	-	Yes	-	Yes	Yes	The study describes the integration and application of VR, AR, and MR in urological practices and the possibilities of medical education using it with increased expectations toward surgical performance and outcomes.
Popov VV *et al.* 2022[5]	-	√	√	√	√	Yes	Yes	-	Yes	The study enumerates Industry 4.0 in healthcare, providing better user comfort through proactive intervention in the early detection and treatment of various diseases. Paradigm shift to its next move toward Industry 5.0. It surveyed modern trends and summarised the intricacies of new features to guide and prepare for an Industry 5.0-ready healthcare system.
Chandra M *et al.* 2022[20]	-	√	√	-	√	Yes	Yes	-	-	Digital technologies and Industry 4.0 tools have the potential to fulfil customized requirements during and after the post-COVID-19 crisis. This research aims to understand healthcare professionals, policymakers, and others, the paradigm of different technologies, tools, and their applications during the COVID-19 pandemic. It reviews Digital technologies, Industry 4.0 tools, and their current and potential applications. The article emphasizes the usefulness, most recent development, and implementation of digital technologies and tools in fighting the COVID-19 pandemic worldwide.
Shah I *et al.* 2022[6]	-	√	√	√	√	Yes	Yes	-	-	This paper reviews the different aspects of human life affected by COVID-19 and discusses various tools and techniques and their integration into people's lives to overcome issues resulting from pandemics. This study covers an up-to-date analysis of blockchain technology, AI, AR/VR, and IoT for dealing with the COVID-19 pandemic considering various applications. These technologies provide new emerging initiatives and discuss challenges and potential research that will promote further research in the future.
Sharma D *et al.*[21]	Correspondence		-	√	√	-	-	Yes	-	No free abstract is available.
Tharion JG *et al.*[22]	√ (RCT)	-	-	√	-	-	-	Yes	-	This RCT uses VR for sedative and analgesic effects. It immerses the patient into an artificial interactive environment with the aim that an immersive experience that engulfs the senses with noninteractive visual and auditory stimuli would have a positive effect on satisfaction and anxiety in 90 patients undergoing spinal anaesthesia for arthroscopic knee surgery. The author found that an immersive experience is an effective and acceptable intraoperative alternative. It works alternative to

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	Original	Review	AR	VR	Others	Indian	Foreign	Indian	Foreign	
										pharmacological sedation in patients undergoing arthroscopic knee. Surgery under spinal anesthesia. It had higher satisfaction levels and no significant difference in preoperative to postoperative anxiolytic effects.
Gunasekeran DV *et al.* 2021[23]	√	-	√	√	-	Yes	Yes	-	Yes	No free abstract is available.
Vadlamani LN *et al.*[24]	√	-	-	√	√	-	-	Yes	-	Telemedicine and telepsychiatry (TP) services in the outpatient department (OPD) have been increasing recently. TP aims to address the treatment gaps, barriers to utilization, accessibility, diagnostic validity, financial implications, and individual client preferences. TP may not replace the traditional in-person consultations completely. The COVID-19 pandemic has hastened its utilization across several healthcare delivery systems. Incorporating big data, machine learning, artificial intelligence, VR, and other technological advances in the psychiatric healthcare delivery systems into TP services in the OPDs would significantly contribute to the overall quality and efficacy of the psychiatric healthcare delivery systems in the future.
Kaul S *et al.* 2020[25]	-	√	-	√	-	-	-	Yes	Yes	No free abstract is available.
Lambert V *et al.*[26]	-	√	-	√	-	-	-	Yes	Yes	The study evaluates the effectiveness and adverse effects of VR distraction interventions for children with acute pain in healthcare settings. Using 17 RCTs, the primary outcome was sharp pain intensity, with other factors including adverse effects, child satisfaction, pain-related distress, parent anxiety, rescue analgesia, and cost. Limited data on adverse effects and secondary products suggest future large, high-quality trials may improve results.
Dananjayan S *et al.*[7]	Brief Report		-	√	√	-	Yes	Yes	-	The 5G technology is bound to transform telemedicine and the healthcare industry. Distance monitoring of patients is possible with wearables facilitated by robust sensors coupled to a 5G network. Virtual patient consultation; AR and VR-based simulated surgeries; artificial intelligence (AI)-powered robotic surgeries; and dynamic huge data repository are some of the other applications of 5G technology in the health sector.
Goldust M *et al.*[27]	Letter to Editor		-	√				Yes	Yes	No free abstract is available
Khullar G *et al.* 2022[28]	√	-	-	√	-	-	-	Yes	-	No free abstract is available
Singh RP *et al.*[29]		√	-	√	-	Yes				A brief review study on VR and its applications for the COVID-19 pandemic using keywords such as Virtual Reality or VR and COVID-19 from the databases. It concludes that VR benefits remote sites for exploring telemedicine, planning, treatment, and controlling infections. It provides proper awareness to the people regarding this disease. It can develop a platform to reduce face-to-face interaction and help to improve surveillance systems on the ongoing situation.

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Author & Reference	Type of article		Technology Description			Technological Organization Contribution		Healthcare Organization Contribution		Description of the article (s)
	Original	Review	AR	VR	Others	Indian	Foreign	Indian	Foreign	
Baniña MC *et al.*[30]	√	-	-	√	-	-	Yes	Yes	Yes	The article studied motor recovery of the upper limb (UL) training in VR applications. It measured how VR programs can deliver high UL exercise intensity and how exercise intensity and difficulty differed among patients. Exercise intensity was high and progressed similarly in all centres. The power attained with this VR exercise program was higher than that reported in current stroke therapy practice. However, progression through different activity levels was similar between centres, and more straightforward guidelines for exercise need to be provided by the VR application. In rehabilitation, VR systems are used to deliver intensive exercise programs.
Pereira KR *et al.*[31]	Short Communication		√	√	√	-	-	Yes	-	Recent decades have witnessed the genesis and progressive application of intelligent machines and computer programs that can process information and execute cognitive functions and reasoning such as problem-solving and decision-making. Healthcare has welcomed AI, giving rise to collaborations such as the Moorfields Eye Hospital and Google's DeepMind division in the screening and predicting of retinal disease.
Syed-Abdul S *et al.*[32]	√	-	-	√	-	Yes	Yes	-	Yes	Study evaluates the effectiveness of VR among older populations as a tool to reduce risks of falls and improve social and emotional well-being using Nine VR applications. Participants used applications of their choice for 15 minutes twice a week for 6 weeks. Participants opine on the Technology Acceptance Model questionnaire and a literature review. They perceived VR as helpful, easy-to-use, and an enjoyable experience, implying positive attitudes toward adopting this new technology and having significant effects on the intention to use VR.
Ateriya N *et al.*[33]	-	√	-	√	√	-	-	Yes	-	The article talks about telemedicine and its reality today as an emerging and essential tool for convenience in remote locations with limited access to standardized healthcare services. However, there are multiple challenges to realizing its full potential. It focuses on critical medicolegal and ethical issues such as the doctor–patient relationship, informed consent, patient rights, malpractice, and confidentiality principles relevant to telemedicine and virtual consultation. It explored the global and Indian legal perspectives on the application of telemedicine and recommended specific legislation.
Kapoor PM 2017[34]	Letter to Editor		-	√	-	-	-	Yes	-	No free abstract is available
Li X *et al.*[35]	√	-	-	√	√	Yes	Yes	-	-	E-healthcare systems enable remote medical services, but medical data privacy is crucial. Amin *et al.* proposed password, biometric, and smart card authentication schemes, but their methods are vulnerable to Denial of Service attacks. A new robust user authentication scheme with privacy protection is proposed, proving more powerful and secure compared to other related schemes.

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	Original	Review	AR	VR	Others	Indian	Foreign	Indian	Foreign	
Kumar D *et al.*[36]	√	-	-	√	√	-	-	Yes	Yes	Stroke is a leading cause of death and disability worldwide. Early detection and treatment can improve healthcare. A quantitative home-based oculomotor assessment tool can aid in stroke prognosis. Rehabilitation platforms, including VR-based exercises, can alleviate disability and improve performance. This research aims to revolutionize healthcare in urban and rural areas.
Sharan D *et al.*[37]	√ (RCT)	-	-	√	-	-	-	Yes	-	The study is based on a rehabilitation program for cerebral palsy children using virtual VRBT and its effect. Twenty-nine subjects participated and collected outcome measures like MACS, PBS, level of participation, motivation, cooperation, and satisfaction of the child, and significant improvements in balance and the manual ability of the study and control groups. PBS was enhanced considerably in the study group (t-t-2.02, P<0.05). The level of participation, motivation, cooperation, and satisfaction of the child were also significantly higher among the study group.
Mahapatra AK *et al.*[2]	√	-	-	√	√	-	-	Yes	-	Advancement in telecommunication, information science, and technology provides an opportunity to exchange knowledge and skills across geographically dispersed organizations by networking with academic institutes to practice distance learning using information and communication technology (ICT)-based tools. These may be as essential web-based tools or as advanced as VR, simulation, and telepresence-based telemedicine and tele-education. The availability of satellite communication technology and the government policy of free bandwidth provision for the societal development sector have added strength to set up infrastructure to pilot several telemedicine educational projects across the country.
Summary	18	12				14	13	23	15	

The major and only limitation of this review article is the search was limited to one database, Pub Med, which is a strength as well based on the reputation of the database articles.

Conclusion

Considering the importance and future potency, AR, VR, and most currently MR, XR, and soft electronic skin are ahead in the healthcare sector, especially in teaching and training for the general physicians practicing at the primary care level. More specifically, the surgical domain can efficiently utilize AR and VR-related technologies in the simulation of surgical cases to train future medical practitioners. Simulation-based training and teaching will reduce real-life errors and improve patient safety at the primary care level.

Key messages

Augmented reality (AR), virtual reality (VR), mixed reality (MR), extended reality (XR), and newer technologies are increasingly being utilized in medical education, despite their global potential, especially in the Indian healthcare sector.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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