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Augmented Reality and Virtual Reality have the potential to transform health care, delivering new types of treatments and diagnostics and changing how and where care is delivered. Central to their potential in diagnosis and treatment is their ability to deliver both standard and entirely new types of content in highly immersive and realistic ways, remotely, and tailored to a variety of clinical contexts. Physicians, patients, and caregivers can enlist AR/VR to help them prepare for, or perform, certain treatments or procedures. On this page:What Is Augmented Reality and Virtual Reality? Augmented Reality (AR) is a real-world augmented experience overlaying or mixing simulated digital imagery with the real world as seen through a camera or display, such as a smartphone or head-mounted or heads-up display (HUD). Digital imagery may be able to interact with real surroundings (often controlled by users). This is sometimes referred to as mixed or merged reality Virtual Reality (VR) is a virtual world immersive experience that may require a headset to completely replace a user's surrounding view with a simulated, immersive, and interactive virtual environment. The term extended reality, or augmented reality and virtual reality, is often enlisted to encompass the two approaches, but for the purposes of this web page, we will use the terms augmented reality and virtual reality.Some real-world examples of AR/VR applications already being used to treat patients include:An AR system that overlays medical images onto a patient during an operation to help guide the surgeon's technique.A VR system that is used to treat post-traumatic stress disorder in army veterans.A VR rehabilitation therapy that simulates real-life situations to improve physical functions for patients who have experienced a physical disability associated with a stroke or other medical conditions.How Are Augmented Reality and Virtual Reality Impacting Medical Devices?This could make it easier and more likely for patients to complete treatment and monitoring regimens. There are a number of treatment domains in which augmented reality and virtual reality are used to treat patients. Among those domains are:Pediatric diagnostics and treatmentsPain managementMental healthNeurological disordersSurgery planningIntraoperative proceduresOphthalmic diagnostics TelemedicineVirtual carePost operative and other rehabilitation therapiesHowever, an AR/VR device may have risks, including risks related to using the device (such as neck pain from the weight of the headset) and risks related to the content and images that the AR/VR technologies provide (such as low contrast images, display errors such as location of anatomy, information overload, dizziness, fatigue, or effects on vision).Examples of probable benefits:Increase access to necessary health care when access is unavailable or in person would be difficultImprove health care professional's ability to prepare for certain treatmentsFulfill unmet medical needsMitigate preoperative anxietyMake procedures less invasiveAccelerate diagnosticsAllow for self-directed careExamples of probable risks:cybersicknessHead and neck strainCybersecurity risksPrivacy risksDistraction in the operating roomEffects of AR/VR on populationsUnknown side effects and/or risks (particularly in pediatrics or other vulnerable populations)Potentially worsening disparities in diagnostics and treatment Augmented Reality and Virtual Reality Medical Devices Questions to Consider If you're a patient, caregiver, or health care professional considering using AR/VR in your health care or practice, the U.S. Food and Drug Administration (FDA) has published these infographics to help you make an informed decision. View the Infographics:List Of Medical Devices that Incorporate Augmented Reality and Virtual RealityThe FDA encourages the development of innovative, safe, and effective medical devices, including devices that incorporate augmented reality and virtual reality (AR/VR).The AR/VR Medical Device List is a resource intended to identify AR/VR medical devices that are authorized for marketing in the United States. Digital health innovators can refer to this list to gain insights into the current market landscape and regulatory expectations, which can help foster innovation and ensure public safety. This list can also provide transparency to healthcare providers and patients to clearly identify when medical devices use AR/VR technologies.Contents of the AR/VR Medical Devices ListThe entries on this list meet the FDA's applicable premarket requirements, including a focused review of the device's intended use and technological characteristics.A direct link to the FDA's database entry of an AR/VR medical device is provided. The database entry contains releasable information, such as summaries of safety and effectiveness, which includes an evaluation of study appropriateness for the device's intended use. Note, the summaries are not all inclusive and do not include most of the information the list is not a comprehensive resource of AR/VR medical devices. Instead, the list includes AR/VR medical devices that were identified primarily based on information provided in the summary descriptions of their marketing authorization document.This list will continue to be updated periodically. AR/VR medical devices that received authorization but for which decision summaries have not been published within the data collection period will be incorporated into a subsequent update.Send questions or feedback on this list to digitalhealth@fda.hhs.gov.AR/VR Medical Devices ListDevices are listed in reverse chronological order by Date of Final Decision. To change the sort order, click the arrows in the column headings.Use the Submission Number link to display the approval, authorization, or clearance information for the device in the appropriate FDA database. The database page will include a link to the FDA's publicly available information.Download a CSV File   Download an Excel File   Save as XML FileTo save the XML file, right click and save the file to your computer and open in the appropriate program Date of Final DecisionSubmission NumberDevice CompanyPanel Code05/16/2025K242569Mixed Reality Spine NavigationBrainlab AGNeurologySBF05/02/2025K243069LUMYS (V1)INTRADYSRadiologyLL203/21/2025K243980ARVIS Surgical Navigation SystemKico Knee Innovation Company Pty LimitedNeurologySBF03/20/2025K243975Knee+Pixee MedicalNeurologySBF03/13/2025K250255xvision Spine systemAugmedics Ltd.NeurologySBF01/14/2025K242205SpectoMed (v1.0)Specto MedicalRadiologyLL201/13/2025K243950ARVIS® ShoulderKico Knee Innovation Company Pty LtdNeurologySBF12/24/2024K243623SpineAR SNAP (SyncAR Spine)Surgical Theater, Inc.NeurologySBF12/04/2024K243417RelieVRxAppliedVRNeurologyQRA10/30/2024K242271Caduceus STaiwan Main Orthopaedic Biotechnology Co., Ltd.NeurologySBF10/21/2024K242058Digital Prism Correction Feature (DPCF)Apple Inc.OphthalmicSCW10/16/2024K241481xvision Spine SystemAugmedics Ltd.NeurologySBF09/10/2024K240094LumiNX US; LumiAugmedit B.V.RadiologyQIH08/19/2024K241870nPoint Augmented Reality Spine SystemOnPoint Surgical, Inc.NeurologySBF08/08/2024K233315HipXpert and HipInsight SystemSurgical Planning Associates, Inc.NeurologyOSF07/26/2024K233725Spine Navigation SystemMedivis, Inc.NeurologyOLO06/13/2024K232309VRRVEOculoMotor TechnologiesOphthalmicSBN05/21/2024K232759Viewer (5.4); Elements Viewer; Mixed Reality Viewer; Smart Layout; Elements Viewer Smart LayoutBrainlab AGRadiologyLL204/24/2024K233172NextAR Spine PlatformMedacta International S.A.OrthopedicOLO03/25/2024K240620Cube NavigatorMedical Templates AGRadiologyLL203/08/2024K230195Neo ADVISE softwareComerge AGNeurologyOLO03/08/2024K233899Knee+Pixee MedicalOrthopedicOLO02/01/2024K232339Augmented Reality ApplicationSira Medical, Inc.RadiologyLL21/205/2023K233568Ceevra Reveal 3+Ceevra, Inc.RadiologyQIH11/02/2023K232176STELLAR KneePolarisAR Inc.OrthopedicOLO10/31/2023K230814VRNTCogniftSense, Inc.Physical MedicineQRA10/29/2023K232280NextAR TSA PlatformMedacta International S.A.OrthopedicOLO10/16/2023K230249IkshanaImmersiveTouch, Inc.RadiologyLL209/25/2023K230825Smileyscope System (Therapy Mode)Smileyscope Holding Inc.Physical MedicineQRA09/14/2023K232139OrionXRHoth Intelligence Inc.RadiologyLL209/08/2023K231284OnPoint Augmented Reality Spine SystemOnPoint Surgical, Inc.OrthopedicOLO09/31/2023K231611HOLO Portal Surgical Guidance SystemSurgalign Spine TechnologiesOrthopedicOLO07/21/2023K223769NextAR Spine PlatformMedacta International S.A.OrthopedicOLO07/14/2023K223290CommandEP Data Manager PC (DPC02), CommandEP HMD (HMD02)SentiAR, Inc.CardiovascularLZ07/13/2023K223X800 (X890-SYS)MediView XR, Inc.RadiologyLL206/13/2023K230567OptiVu ROSA® MxROrthosoft, Inc. (d/b/a Zimmer CAS)OrthopedicOLO05/24/2023K223035Avatar Medical Software V1Avatar MedicalRadiologyLL205/01/2023K221870CarnaLife HoloMedApp S.A.RadiologyLL204/25/2023K222676Ceevra Reveal 3Ceevra, Inc.RadiologyQIH04/21/2023K230789Knee+Pixee MedicalOrthopedicOLO02/24/2023K222757Clarus ViewerClarus Viewer CorporationRadiologyLL201/20/2023K222510Blueprint Mixed Reality systemTornier SASNeurologyOLO12/30/2022K221796Cyware 4H and Cysart 4HAbys MedicalRadiologyLLZ12/16/2022K220554Caduceus STaiwan Main Orthopaedic Biotechnology Co., Ltd.NeurologyOLO11/25/2022K213215VSI HoloMedicineApoQlar GmbHRadiologyLLZ11/17/2022K220905xvision Spine SystemAugmedics Ltd.OrthopedicOLO11/04/2022K221659Luminopia OneLuminopia, Inc.OphthalmicQQU10/21/2022K213128IntraOp VSP Software DeviceXironetic, LLCRadiologyLLZ09/29/2022K213034SpineAR SNAPSurgical Theater, Inc.OrthopedicOLO09/01/2022K220104Knee+Pixee MedicalOrthopedicOLO07/29/2022K220733OptiVu ROSA MxROrthosoft, Inc. (d/b/a Zimmer CAS)OrthopedicOLO07/12/2022K221098Scopis ENT Software, Scopis ENT Software with TGS, Scopis Planning Software, Electromagnetic Navigation UnitStryker CorporationEar, Nose, & ThroatPGW06/15/2022K213684SurgiCase ViewerMaterialise NVRadiologyLLZ05/27/2022K220146VisARNovarad CorporationOrthopedicOLO03/10/2022K213751NextAR TKA Platform My Knee PPSMedacta International S.A.OrthopedicOLO01/14/2022K211254ARAI Surgical Navigation SystemScopis TechnologiesOrthopedicOLO11/16/2021DEN210014 AMvision VisionOS PrecisionOS Technology Inc.RadiologyLLZ11/05/2021K210859NextAR Spine PlatformMedacta International S.A.OrthopedicOLO10/20/2021DEN210005Luminopia OneLuminopia, Inc.OphthalmicQQU10/02/2021K202927EYE-SYNCSyncThink, Inc.NeurologyQEA09/29/2021K210726ImmersiveTouchImmersiveTouch, Inc.RadiologyLLZ07/19/2021K211188xvision Spine system (XVS)Augmedics Ltd.OrthopedicOLO07/14/2021K203115ARVIS Surgical Navigation SystemInsight Medical Systems Inc.OrthopedicOLO05/14/2021K210072HOLOSCOPE-iReal View Imaging Ltd.RadiologyLLZ05/12/2021K210153NextAR RSA PlatformMedacta International S.A.OrthopedicOLO04/21/2021K202750Knee+Pixee MedicalOrthopedicOLO01/28/2021K200384HipXpert 3D Display and Anchoring ApplicationSurgical Planning Associates, IncOrthopedicOSF10/27/2020K202152NextAR TKA PlatformMedacta International S.A.OrthopedicOLO09/18/2020K192890SentiEPSentiAR, Inc.CardiovascularLZ07/17/2020K201465Surgical Planner (SRP) BrainStormSurgical Theater, Inc.RadiologyLLZ07/10/2020K193559NextAR TKA PlatformMedacta International S.A.OrthopedicPBF01/23/2020K191014Elements ViewerBrainlab AGRadiologyLLZ12/20/2019K190929xvision Spine system (XVS)Augmedics Ltd.OrthopedicOLO11/29/2019K191918I-Portal Neuro Otologic Test Center, I-Portal Video Nystagmography System, I-Portal Portable Assessment System - NysragmographNeurolign USA, LLCEar, Nose, & ThroatGWN08/29/2019K183489D2P3D Systems, Inc.RadiologyLLZ05/13/2019K190764SurgicalARMedivis, Inc.RadiologyLLZ03/18/2019K183296REAL Immersive SystemPenumbra, Inc.Physical MedicineISD02/22/2019K182643IRIS 1.0 SystemIntuitive SurgicalRadiologyLLZ02/14/2019K190074Presero 3D Scanning SystemCertis HealthGeneral & Plastic SurgeryLLZ09/21/2018K172418OpenSightNovarad CorporationRadiologyLLZ07/10/2018K173274Ceevra Reveal 2.0Ceevra, Inc.RadiologyLLZ02/12/2018K170793SuRgical Planner (SRP)Surgical Theater, LLCRadiologyLLZ08/03/2017K171356Clarity RevealCeevra, Inc.RadiologyLLZ04/24/2017K162748MindMotionPROMindMaze SAPhysical MedicineLXJ03/03/2017K170167True 3D Viewer SoftwareEchoPixel Inc.RadiologyLLZ02/28/2017K143205Virtual Occupational Therapy Application (VOTA)Barron Associates, Inc.Physical MedicineLXJ06/28/2016K160584Surgical Navigation Advanced Platform (SNAP)Surgical Theater, LLCRadiologyLLZ02/12/2016K153004Clear Guide SCENERGYClear Guide MedicalRadiologyLLZ02/05/2015K151935YuGo SystemBioGaming LTD.Physical MedicineLXJ01/29/2016K152915EYE-SYNCSyncThink, Inc.NeurologyGWN01/21/2015K141017ECHO TRUE 3D VIEWERechoPixel, Inc.RadiologyLLZ Augmented reality (AR) changes the way medical professionals train, conduct procedures, and engage patients. From supporting complex surgeries to enhancing patient understanding, AR helps improve accuracy, safety, and care accessibility across healthcare settings. This guide explores the top use cases, benefits and real-life applications, including how next-level medical visualization software development companies like VOKA are making a difference in medical education.What is augmented reality?Augmented reality (AR) is a technology that enhances the physical world by overlaying digital information—like images, data, and 3D models—onto real environments. Unlike virtual reality, which immerses users in an entirely digital space, AR adds valuable layers of information to the world around us. The technology provides an interactive experience that keeps users grounded in their actual surroundings.In essence, AR is health technology that bridges the gap between digital insights and real-world applications, making interactive, interactive, and transformative for both professionals and patients.How AR is transforming the healthcare industryAR is a game-changer. By integrating medical data directly into a clinician's field of view, AR helps visualize patient anatomy, treatment plans, and diagnostic information in real-time, making complex medical details easier to understand and apply. For example, surgeons can see overlays of internal structures while operating, guiding their actions and improving precision.AR also makes patient education more impactful, as patients can visualize their own anatomy and treatments in 3D, enhancing understanding and engagement. For medical students, AR provides an interactive way to study anatomy and practice procedures, bringing textbook concepts to life without needing physical specimens.The role of AR in healthcareAugmented reality (AR) is changing the way we do healthcare by combining digital information with the real world. This technology uses computer vision, depth sensing, and spatial mapping to do some pretty amazing things. In surgery, AR overlays 3D anatomical models right onto the patient, giving surgeons a real-time, interactive roadmap for tricky procedures. Studies show this helps make sure things like tumor removal and laparoscopic surgery are done right the first time, which makes patients happier.AR is also great for medical training. Students can play around with realistic 3D anatomy and practice in simulated scenarios, which helps them learn faster and get better at hands-on stuff. Unlike VR, which creates a whole separate digital world, AR lets doctors stay grounded in their real surroundings, so they can get real-time help during procedures and training.By showing key data, giving awesome anatomical views and letting users play with interactive simulations, AR helps to bridge the gap between what you know in theory and what you know in practice. This makes things more accurate, efficient and easier for patients to grasp. Plus, AR gives patients a better understanding of their own bodies and medical conditions, which helps them make informed decisions about their care.Top 6 use cases of augmented reality in healthcareAugmented reality offers immersive, interactive healthcare solutions that benefit both patients and medical professionals. Custom AR development services for healthcare enable institutions to tailor AR applications to their unique needs, enhancing patient care, surgical accuracy to patient education. Here are seven key ways AR is used in healthcare, transforming clinical practice and patient outcomes.1. Surgical planning and assistanceAugmented reality (AR) extends the capabilities of surgical planning and assistance by providing critical real-time data and visualization directly within the surgical field. With overlay of 3D images of a patient's anatomy or scans, AR enhances surgical precision, enabling surgeons to visualize crucial details like arteries, nerves, or tumors with "see-through" vision, particularly valuable in minimally invasive surgeries.This real-time guidance acts as a digital roadmap of the patient's body, improving spatial orientation and facilitating faster, more confident decision-making during procedures. In complex surgeries, such as neurosurgery, AR offers invaluable assistance; for example, in brain surgery, it allows precise mapping of critical regions like motor or speech areas, enhancing safety.Ultimately, AR benefits not only surgeons and patients: surgeons gain clearer visualization and improved decision-making confidence, while patients experience fewer complications, reduced recovery times, and improved surgical accuracy.Use case: VOKA surgical assistantAR overlays VOKA's 3D anatomical models and surgical plans directly onto the surgeon's view of the patient during the procedure. This allows for real-time, "see-through" guidance and precise manipulation of instruments.2. Medical training and educationAugmented reality (AR) is changing the game in medical training and education. It's moving beyond traditional methods like cadavers and textbooks to offer dynamic, interactive learning. AR uses 3D medical models to make anatomy come alive, letting students explore organs, tissues, and skeletal structures from every angle, which helps them understand how all the body systems are connected. Such an approach improves knowledge retention and spatial reasoning, crucial for surgical specialties.What's more, AR facilitates simulated procedures like suturing and incisions in a risk-free virtual environment. This hands-on practice builds crucial skills and allows repetition without patient risk, potentially shortening the learning curve. With AR's integration into anatomy education providing virtual dissection experiences rivaling real-life dissections in detail, increasing student engagement and comprehension. This technology also offers benefits for educators, enabling them to explain complex topics more effectively and tailor instruction to individual learning styles.Use case: VOKA 3D Anatomy & PathologyVOKA 3D Anatomy & Pathology offers hyper-realistic 3D models of normal anatomy and gross pathology, viewable in AR, providing students and professionals with an unprecedented, detailed look at human anatomy.3. Patient education and engagementAugmented reality (AR) is the future of patient education and engagement. It's going to transform the often intimidating experience of healthcare into one that's intuitive and transparent. Furthermore, AR allows for risk-free exploration of treatment plans in a virtual environment. This hands-on engagement allows patients to make informed decisions and actively participate in their care.AR integration into patient education provides personalized visualizations tailored to individual needs, increasing patient engagement and satisfaction.AR-based education improves patient adherence to treatment plans and leads to better health outcomes. This technology also offers benefits for healthcare providers, enabling them to explain complex topics more effectively and build stronger patient-provider relationships.Use case: VOKA MoA and MoD animations for patient engagementAR presents VOKA's animations in an engaging and interactive format. Patients can visualize complex medical concepts in 3D, promoting better understanding and adherence to treatment plans.4. Rehabilitation and physical therapyAugmented reality (AR) is changing the game in rehabilitation and physical therapy. It's moving beyond traditional exercises and manual feedback to offer dynamic, interactive recovery programs that get results. AR uses motion tracking and virtual environments to create engaging therapeutic experiences. Patients can perform exercises in a gamified setting and see their progress in real time. This immersive approach boosts motivation and ensures patients stick to their therapy programmes.Also, AR allows for the creation of personalized exercise programmes that are tailored to individual needs and recovery goals. This customized approach guarantees optimal recovery outcomes and minimizes the risk of re-injury. Integrating AR into physical therapy provides real-time feedback on movement quality and performance, increasing patient engagement and promoting proper exercise technique. Studies prove that AR-based rehabilitation accelerates recovery and improves functional outcomes in various patient populations. This technology also offers significant benefits for therapists, enabling them to monitor patient progress remotely and adjust treatment plans as needed. The future is bright for AR in rehabilitation. It will become even more personalized, adapting to each patient's progress and providing targeted therapeutic interventions.Use case: VOKA rehabilitation assistantAR integrates VOKA's 3D models with motion tracking technology. This allows patients to receive real-time feedback on their exercises, ensuring proper form and technique.5. Remote consultations and virtual collaborationBridging geographical barriers and expanding access to specialized care, augmented reality (AR) is enhancing remote consultations and virtual collaboration in healthcare. Moving beyond traditional video conferencing, AR offers interactive 3D visualizations. AR uses spatial computing and shared virtual spaces to connect doctors and specialists to examine patients remotely and collaborate on diagnoses and treatment plans. This interactive approach improves communication and facilitates shared decision-making.Additionally, AR facilitates real-time access to patient medical data and 3D anatomical models. This enhanced visualization empowers healthcare providers to make more informed decisions and deliver personalized care. AR's integration into telemedicine provides a valuable tool for remote diagnosis and treatment planning, increasing access to specialized care and improving patient outcomes. Studies suggest AR-based telemedicine can reduce healthcare costs and improve patient satisfaction. This technology also offers benefits for healthcare systems, enabling them to extend the reach of specialized care and improve the efficiency of healthcare delivery. Looking ahead, AR holds the potential to transform remote healthcare further, bridging geographical barriers and connecting patients with specialists worldwide.Use case: VOKA virtual consultation suiteAR allows doctors and patients to interact with VOKA's 3D anatomical models during remote consultations. This shared virtual platform facilitates clearer communication and collaborative decision-making.6. Facility management and surgical room preparationMoving beyond traditional blueprints and manual checklists, AR offers dynamic, interactive tools. AR uses 3D models and spatial mapping to create virtual representations of hospital environments, allowing administrators and staff to visualize room layouts, optimize equipment placement, and streamline workflows. This interactive approach enhances efficiency and reduces the risk of errors.Furthermore, AR facilitates real-time tracking of equipment and resources, ensuring that surgical teams have the necessary tools readily available. This optimized resource management improves surgical workflow and enhances patient safety. AR's integration into facility management provides valuable data-driven insights into space utilization and resource allocation, increasing operational efficiency and reducing costs. Studies suggest AR-based surgical room preparation can reduce setup time and improve surgical team performance. This technology also offers benefits for hospital administrators, enabling them to plan and manage facility resources more effectively. Looking ahead, AR holds the potential to transform hospital operations further, creating smart hospitals that leverage real-time data and automation to deliver optimal patient care.Use case: VOKA facility management suiteAR utilizes VOKA's 3D models and spatial mapping to create virtual representations of hospital environments. This allows for efficient planning of room layouts, equipment placement, and resource management.Benefits of AR in healthcareAugmented reality is enhancing healthcare by offering real-time, interactive solutions that elevate patient care, improve procedural accuracy, and streamline educational experiences. One of the most significant benefits of AR is its ability to increase surgical precision. By overlaying critical data and 3D models onto a patient's body during procedures, surgeons have a clearer roadmap, minimizing risks and improving accuracy. AR also greatly benefits patient education—patients can visualize their own diagnoses, treatments, and the effects of their care. AR fosters a better understanding and encourages active involvement in their care. For medical students and professionals, AR offers immersive training tools that allow them to practice procedures, and develop skills in a controlled, interactive environment, leading to a more confident and skilled healthcare workforce.Challenges and limitations of AR in HealthcareWhile the potential of AR in healthcare is vast, several challenges hinder its widespread adoption. One primary limitation is the high cost of AR technology, which can be prohibitive for smaller healthcare providers. This includes the expense of AR hardware, software development, and maintenance, as well as the infrastructure required to support seamless AR applications.Data privacy and security are also significant concerns, especially as AR systems rely on sensitive patient information. Implementing robust data protection measures is essential but can be complex and costly. Additionally, AR in healthcare requires extensive training to ensure that practitioners can use the technology accurately and effectively; any misinterpretation or delay in AR visualizations could negatively impact patient safety.Finally, there are ongoing regulatory challenges, as AR applications need to meet strict compliance standards to ensure safety and efficacy in clinical settings.The future of AR in healthcareThe future of AR in healthcare looks promising as technology becomes more accessible, affordable, and advanced. As AR hardware evolves, expect to see more compact, powerful devices that are easier to integrate into everyday medical practice. Software advancements will allow for greater accuracy and real-time adjustments, making AR an even more powerful tool for clinicians and medical procedures.As the healthcare sector continues to embrace digital transformation, AR will expand its reach into more specialties, supporting remote diagnostics, personalized treatment plans, and even patient-led care through home AR applications. With ongoing research and development, AR in healthcare could evolve from an innovative option to a standard tool across medical practices, fundamentally changing how healthcare professionals diagnose, treat, and educate.Read our new case studiesConclusionAugmented reality is reshaping healthcare by bridging the gap between digital data and real-world applications, offering tools that enhance surgical precision, streamline medical education, and improve patient engagement. With applications that range from surgical planning and training to patient education and mental health support, AR is proving to be a transformative force.In medical training, softwares like VOKA 3D Anatomy & Pathology exemplify how AR can provide detailed, interactive models that boost understanding and skill acquisition. While challenges remain in cost, data security, and regulatory compliance, AR's future in healthcare is bright.As the technology advances, it promises a more personalized, efficient, and informed approach to healthcare, setting new standards for excellence in the healthcare industry. Enjoy sharper detail, more accurate color, lifelike lighting, believable backgrounds, and more with our new model update. Your generated images will be more polished than ever.See What's NewExplore how consumers want to see climate stories told today, and what that means for your visuals.Download Our Latest VisualGPS ReportData-backed trends. Generative AI demos. 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Inclusion in an NLM database does not imply endorsement of, or agreement with, the contents by NLM or the National Institutes of Health. Learn more: PMC Disclaimer | PMC Copyright Notice Virtual reality (VR) and augmented reality (AR) are rapidly gaining traction in healthcare, offering transformative opportunities for patient care, medical education, and therapeutic interventions. Despite their potential, challenges remain regarding the implementation and integration of these technologies into existing healthcare practices. This review aims to explore the current applications of VR and AR in healthcare, particularly focusing on their roles in enhancing patient care and medical training, as well as identifying research gaps that hinder their widespread adoption. A comprehensive literature search was conducted across 2 primary databases, PubMed, and Google Scholar. The search was restricted to peer-reviewed articles, systematic reviews, meta-analyses, and randomized controlled trials (RCTs) published from 2000 to 2024. Reference lists of included articles were also examined for additional relevant studies. Inclusion criteria focused on empirical studies addressing the use of VR and/or AR in patient care or medical training, while editorial pieces, non-peer-reviewed sources, and unrelated studies were excluded. A total of 17 900 search results were identified on Google Scholar and 300 on PubMed, leading to the inclusion of 89 articles in this review. The findings indicate that VR and AR technologies significantly enhance patient experiences and medical training, providing immersive and interactive environments for learning and practice. However, notable challenges include integration issues with existing electronic health record systems, the need for appropriate implementation models, and a lack of substantial evidence supporting the clinical efficacy of AR-assisted procedures. While VR and AR hold considerable promise in revolutionizing healthcare practices, further research is essential to address existing gaps, particularly regarding implementation strategies, user acceptance, and empirical evaluation of patient outcomes and training effectiveness. Understanding the needs of healthcare professionals and patients will be critical to maximizing the impact of these technologies in clinical settings.Keywords: virtual reality, augmented reality, patient care, medical education, medical training Virtual reality (VR) is gaining popularity in healthcare settings, as new technological breakthroughs enable diagnosis and therapy. 1 VR, as indicated by its name, involves the use of a specialized headset to simulate an environment in which the user is fully immersed, thus creating the perceptual experience of being physically situated in a synthetic 3-dimensional (3D) virtual space and offering diverse avenues for engaging with virtual environments or characters. These virtual characters, commonly called avatars, enhance the user experience and facilitate meaningful interactions. 2 Closely related to the elements of VR, augmented reality (AR) connects to it and displays a real-world environment in the form of a live video, where the user can interact with the help of haptic (touch) feedback and audio and visual stimuli.3,4 In recent years, technological advancements have made VR and AR systems portable, realistic, and user-friendly for real-time navigation. These systems often include sensory and olfactory elements within a range of sensations. 5 Personalized VR and AR devices have been available in the market for several years and continue to evolve and improve. Users can interact with virtual environments using handheld devices, such as joysticks or keyboards, and more recently, through integrated body tracking technology.5,6 VR and AR are highly versatile and utilize various systems and setups to accommodate a wide range of content. This content can range from highly immersive, dynamic, and interactive experiences to non-immersive and static ones.6,7 Despite their potential benefits, the successful utilization of VR and AR necessitates complete integration into current healthcare practices and should be in accordance with the requirements of patients and healthcare professionals. Thus, focusing on implementation strategies is crucial to increasing technological acceptance, uptake, and impact. The rising stress in public health systems has created a demand for more advanced solutions, which is one of the reasons for the rapid development of AR and VR. 8 There are numerous advantages to using VR or AR over traditional therapies. These technologies could enable multiple repetitions of simple tasks in a clinical setting within an immersive environment, reducing the need for constant supervision by the medical staff, which could significantly lower the costs associated with training facilities. 1 As technology continues to advance in the healthcare sector, VR is becoming increasingly popular in healthcare settings for diagnostic and therapeutic purposes. Although implementation interventions may aid in the systematic adoption of VR, they are rarely used in practice. Using an implementation model to guide the process can inspire methodical implementation and aid in the development of an intervention. While a large number of implementation models have been established, there is still limited use of these models to structure the adoption of VR in healthcare. 9 Similarly, AR-based technology is revolutionizing various aspects of healthcare and offering unprecedented opportunities for medical imaging and visualization, anatomy education, and telemedicine. 10 The integration of AR into healthcare practices enhances the effectiveness of medical care, leading to improved patient care by increasing patient adherence to treatment and improving the quality of care, AR also alleviates the overall burden on the healthcare system. Additionally, AR holds significant potential as an effective learning methodology for patients, warranting a comprehensive overview of its current status in patient education and health literacy. 11 VR signifies a change in the approach to educating and assessing the proficiency of healthcare providers. The notion of VR was first proposed in the 1960s by Morton, who created the "Tele Sphere Mask" and the "Sensorama." The initial technologies were designed to immerse the viewer in a video display environment, inducing a sensation of being integrated into the video experience. 12 Ivan Sutherland created the "Ultimate Display," regarded on a comparable premise, enabling the user to experience immersion in a virtual environment by employing various input and output devices. The introduction of Sensorama and the concept of the Ultimate Display in the 1960s, the next significant surge in VR technology development occurred in the early 2010s.13,14 Although VR was developed in the 1950s, AR and VR were not interchangeably until 1968, when AR was categorized as a separate entity for the first time and users were able to experience it using a head-mounted display (HMD). In the 1990s, Caudell developed an early prototype, which is being further developed and enhanced to this day. Reflecting the continuous progress in AR technology, the first Google Glass model was launched in 2013, followed by Microsoft's HoloLens in 2016. Since then, both companies have introduced new versions. 15 The area continues to be dynamic as VR and AR technologies evolve and become increasingly integrated into various industries. Despite the promising advancements in VR and AR technologies within healthcare (refer to Figure 1), several research gaps persist that warrant further exploration. There is a notable scarcity of implementation models that effectively guide the systematic adoption of VR and AR in clinical settings, hindering their full integration into established healthcare practices. Although the benefits of these technologies in enhancing patient education and health literacy are recognized, there is limited empirical evidence evaluating their impact on patient adherence and treatment outcomes. Therefore, more research is needed to understand the specific needs and preferences of healthcare professionals and patients when incorporating these technologies, as well as the technological acceptance and usability in diverse healthcare environments. Addressing these gaps is crucial for maximizing the potential of VR and AR in transforming patient care and training paradigms. Virtual and augmented reality applications in healthcare. A comprehensive research was conducted using 2 primary databases: PubMed and Google Scholar. The search focused on identifying relevant studies discussing the applications of VR and AR in healthcare, particularly in patient care and medical training. The following search terms were used: ("Virtual Reality" OR "Augmented Reality") AND ("Patient Care" OR "Medical Training") AND ("Surgical Training" OR "Medical Education"). The search was limited to peer-reviewed journal articles, systematic reviews, meta-analyses, review articles, and randomized controlled trials (RCTs), published between 2000 and 2024. In addition, the reference lists of included articles were examined. Studies that addressed the use of VR and/or AR in patient care or medical training, published in English, with full-text availability, and those presenting empirical data were included. Editorials, non-peer-reviewed sources, conference proceedings, and studies unrelated to healthcare applications of VR/AR were excluded. Studies that did not explicitly measure patient outcomes, training efficacy, or clinical integration were also excluded. Approximately, 17,900 search results were obtained on Google Scholar, and 300 results were found on PubMed. Among these, we included 89 articles in our study. Patients frequently perceive the hospital as an "unfriendly" environment because of several factors such as overwhelming noise, loss of personal autonomy, and insufficient information. 16 This is exacerbated by stress and anxiety, both of which are recognized as major risk factors for various mental health disorders, including depression and anxiety disorders, as well as physical health issues, such as cardiovascular disease. To reduce the attention available for conscious processing of stress and anxiety, VR is often used to provide straightforward distractions, for example, watching videos or playing video games. While the exact physical mechanisms are not fully understood, this approach shifts the patient's focus away from conscious awareness of stressful situations during occupational activity. 17 In a recent study, Chiu et al 18 examined the effects of a VR preoperative education program on lowering anxiety levels in adult patients scheduled for elective surgery. The findings demonstrated that VR-based interventions are both feasible and effective in mitigating preoperative anxiety. While patients can learn pain-management techniques, such as mindfulness, several experimental results suggest that VR techniques have actual benefits for subjective pain reduction. For example, Oculus Rift uses DEEP, a meditation application, to help users breathe deeply. The application works through a head surrounding the chest to measure the breathing rate. In another pilot study, 44 participants attended a mindfulness conference on an Oculus Rift 2VR helmet and floated down a calm 3D computer-generated virtual river while listening to digitized DBT mindfulness skills training instructions. Participants reported significantly less sadness, anger, and anxiety, but more relaxation. 19 Virtual reality exposure therapy (VRET) trials for anxiety-related disorders have proliferated in number and diversity. 20 Dr. Spiegel's team at the Cedars-Sinai Hospital has given chronic patients the opportunity to get out of the hospital through VR and to enjoy the natural scenery. This could reduce a patient's stress and shorten hospital stays. 21 Relaxation and meditation in various VR applications have become increasingly widespread for treating patients at home or in hospitals. 22 Research conducted at the University of Barcelona has demonstrated that using VR with depressed patients can lessen the severity of their depression and self-degradation while enhancing their overall satisfaction. 23 By minimizing real-world distractions and enhancing the sense of presence, VR can facilitate mindfulness practice. To improve pain management in hospitalized patients, physical and psychosocial treatments must be provided concurrently due to the multifaceted nature of pain, whether acute, intermittent, or chronic. 24 The introduction of VR technology in 1998 by Hoffman marked a significant advancement in pain management, demonstrating its efficacy in reducing burn-related pain and managing pain in various conditions.25,26 Acute pain triggered by surgery or trauma elicits nociceptor activation, leading to inflammatory, physiological, and behavioral responses, often associated with pharmacological therapies.27,28 VR technology offers new possibilities for severe pain treatment, as evidenced by studies exploring the effectiveness of VR-based games in alleviating acute pain. 29 There is strong evidence supporting the effectiveness of VR in managing chronic and post-operative pain. 17 Mosso-Vázquez et al 30 enrolled 67 patients following cardiac surgery and provided them with a VR intervention featuring various immersive environments. After the VR sessions, 59 patients (88%) reported a reduction in pain levels, as measured by a Likert Scale. In a recent study, Hoffmann et al 31 tested a VR game with 48 burn victims aged 6 to 17 years during wound cleaning procedures. The results showed a significant reduction in self-reported pain compared to the control group. However, Faber et al 32 discovered that the effectiveness of repeated VR interventions may diminish over time with frequent use. Augmenting hypnosis with VR technology, known as virtual reality hypnosis (VRH), has shown promise in reducing pain and anxiety. 33 While research on VR for chronic pain management is limited, studies have investigated its potential in conditions like complex regional pain syndrome, demonstrating improvements in analgesic efficacy. 34 Trucker-based VR systems have also been explored for chronic neck pain, showing associations with cervical range of motion, relevant to chronic neck pain pathophysiology. 35 Other research groups have also examined the practicality of VR applications in routine clinical settings. Markus et al 36 reported that the entire process—including VR setup, instruction, therapy, and cleaning—took 59 min. Creating a calm environment and employing relaxation techniques can significantly reduce stress in the intensive care unit (ICU). This is an area where VR excels. 3 Delirium affects between 35% and 80% of ICU patients, whether ventilated or non-ventilated, and is linked to prolonged hospital stays and higher mortality rates. 37 Given that pharmacological treatments frequently come with undesirable and severe side effects, non-pharmacologic approaches are crucial for treating and potentially preventing delirium. 38 The E-CHOSIR (Electronic-CHOice of a various CHOice in patient Relaxation) trial demonstrated the beneficial effects of VR. In this study, 60 alert and non-delirious ICU patients were randomized into 4 groups for relaxation sessions: standard relaxation with television or radio, music therapy, and 2 virtual reality systems featuring either real motion pictures or synthetic motion pictures. The results showed a significant reduction in overall discomfort and stress response in the group exposed to synthetic motion pictures. Both VR systems effectively reduced anxiety; however, only the synthetic motion pictures group experienced lower subjective pain levels. While 3 incidents of claustrophobia, dyspnea, and agitation occurred during the VR sessions, instances of cybersickness were infrequent. 39 Gerber et al40,41 obtained comparable outcomes in their study, where they utilized VR featuring immersive nature scenes with 33 critically ill patients' post-cardiac surgery. The acceptance of VR was high among patients, with most reporting positive effects on stress levels. These findings were corroborated by a reduction in respiratory rate during the VR sessions. VR has also shown positive effects on sleep quality, in a randomized controlled trial involving 48 ICU patients, the use of VR led to significantly improved sleep quality, although there was no difference in total sleep time and light sleep time between the groups. 42 In conclusion, numerous studies suggest that VR has a beneficial impact on stress, anxiety, and delirium in critically ill patients. Prolonged ICU stay adversely affects both short and long-term outcomes. VR applications can aid in supporting rehabilitation programs in the ICU. Gomes et al 43 investigated the use of VR for adult ICU patients without mobility restrictions, aiming to enhance their physical activity. After 100 sessions, 86% of patients expressed a desire to continue using the video game in future physical therapy sessions. Abdulsatar et al 44 evaluated the same gaming platform (Nintendo Wii™) in a pilot trial involving 12 critically ill children. Upper limb activity increased significantly during the Wii™ sessions and no adverse events were attributed to the VR intervention. A study by Parke et al 45 aimed to enhance early ICU mobilization using VR support. Twenty adult ICU patients participated in these physiotherapy sessions utilizing the Jintronix virtual image system, which targeted arm, leg, and trunk strength, as well as endurance exercises. The primary objective of this investigation was to assess safety and feasibility, which was successfully achieved. However, nearly all participants reported that the VR activity was enjoyable, improved their body strength and range of motion, and motivated them to continue exercising. Furthermore, Wang et al 46 developed a VR application through motor mobilization of critically ill patients, although it has not yet been evaluated in either patients or evaluators. Similar to other fields, VR in radiology offers users an immersive 3D experience through navigation. Early pilot models designed to replicate radiological suite features, such as the one used by King et al, 47 utilized an Oculus Rift HMD system and the 3DSlicer software program to view multiple individual slices of serial CT scans. Users could interact with the displayed images using a commercial gaming controller, allowing them to adjust the window width and level. More recent efforts, such as VRRRRoom, employed similar HMD hardware along with a multi-touch frame on a desk surface to enable touch-based input. 48 For visualization, 3D reconstructed models created from individual CT slices were projected onto the desk surface, allowing users to manipulate them through various interactive features. Efforts are currently underway to develop a VR radiology reading room equipped with a fully digital picture archiving and communication system (PACS) workstation. For instance, sieVRt (Luxsonic Technologies, Saskatoon, SK) has recently become Canada's first commercially available VR Digital Imaging and Communications in Medicine (DICOM) viewer. This web-based software is compatible with commercial high-grade VR HMDs and haptic feedback controllers, creating an interactive and potentially distraction-free radiology reading room experience, as elaborated in Figure 2. Users can display negatoscope image stacks, adjust window width and level, annotate, and mark images, and perform various measurements, such as lengths, angles, and pixel densities. 49 Cases can be retrieved from a local image repository and displayed virtually on a comprehensive DICOM viewer with up to 3 virtual monitors. The software can integrate with existing PACS, radiology information systems (RIS), and reporting software to seamlessly fit into current workflow practices. The interface also includes built-in collaboration tools, enabling multiple users to review and discuss cases simultaneously within the virtual environment. This technology aims to enhance the accessibility of medical imaging, allowing radiologists to utilize their personalized reading room wherever they are. A schematic diagram showing how virtual reality hardware and software are utilized to construct a virtual human structures better than ever before, enabling them to be highly accurate in various types of surgeries. It was used during dental implant surgery to display alveolar nerve bundles and visualize osseous structures during surgery, which helped avoid damaging important structures within the confined area. 50 Anatomical imaging can also aid in reducing complications and improving overall outcomes during vascular and endovascular surgery. 51 Real-time AR reconstructions projected onto patients for percutaneous and endovascular interventions during surgery. A pilot study revealed that examining VR reconstructions of splenic artery aneurysms prior to endovascular embolization increased operator confidence. 52 In a comprehensive review by Goo et al, 53 it was demonstrated that AR could be particularly beneficial for minimally invasive cardiac interventions or surgeries. Moreover, AR-enhanced transesophageal echocardiography (TEE) can assist in determining the optimal annuloplasty ring size, especially for surgeons with limited experience, and in performing percutaneous mitral valve repairs. 54 Despite challenges related to patient movement and image mismatch when using AR, advancements in image reconstruction have greatly enhanced the accuracy of lesion localization. These improvements have achieved a discrepancy of less than 5 mm between marked and real distances. 55 Currently, studies assessing the objective advantages of AR compared to conventional localization methods in interventional radiology, such as "road-mapping with fluoroscopy," are limited. More comprehensive demonstrations are necessary to confirm its clinical utility. AR can be particularly beneficial for telemedicine, remote assistance, and patient education. 56 First responders have a very tough job, which requires fast and accurate triage of patients to expedite the treatment process. With the help of AR, first responders' accuracy in triaging patients was much greater with only a small increase in time duration when compared to responders who did not use AR. 57 AR also shows benefits during remote post-surgical wound assessment. Using a Microsoft HoloLens, surgeons were able to accurately assess the negative pressure wounds remotely through a live video feed. This ultimately led to a decrease in unplanned surgical revisions and improved patient satisfaction. 58 Likewise, AR-compatible Microsoft HoloLens became a life-saving asset during COVID-19. A senior team member used the lens while rotating in COVID-19 wards, while other team members could virtually aid the team, reducing exposure and conserving personal protective equipment (PPE). 59 One of the primary contributions of the HoloLens2 was its role in reducing the risk of infection transmission by enabling remote diagnostics and consultations. This technological integration allowed healthcare workers to maintain necessary interactions without physical proximity to patients. The positive outcomes from using the HoloLens2 could encourage further exploration and adoption of augmented and virtual technologies in healthcare, particularly in training and remote care scenarios. During surgery, AR allows surgeons to superimpose their view of the surgical field with digital images, particularly highlighting tumors, and anatomical structures. In the context of minimally invasive surgery (MIS), AR has demonstrated great potential as a complementary tool with numerous breakthroughs and research initiatives underway. 60 Felix et al 61 conducted a study in which 7 cadavers were included requiring pedicle screw insertion using VisAR (HoloLens 2 headset). 61 The use of AR-guided navigation system significantly improved the accuracy of pedicle screw insertion, suggesting that integrating AR technology into spinal surgery practices can enhance surgical precision, and optimize clinical outcomes. Stereotactic neurosurgery is a well-established technique, yet it presents several limitations. Frameless stereotaxy with neuronavigation necessitates that surgeons divert their attention from the surgical field to the navigation display and maneuver the needle while maintaining an ergonomically challenging position. Satoh et al 62 noted that several researchers have documented the use of frameless stereotaxy integrated with AR to project the needle trajectory onto the patient's posture. Endoscopic procedures have become an essential component of all surgical disciplines and are now considered standard practice. Conventional laparoscopy has been upgraded to include dynamic forms of minimally invasive surgery in contemporary practice. Enhanced visualization through 3D technology and the extension of surgical instruments to 7 degrees of freedom enable the application of minimally invasive techniques even in complex surgical scenarios. Guidance provided by robot-assisted tools enables surgeons to operate with reduced tremors and fatigue, offering significant benefits to both surgeons and patients.63-65 Central line placement and intubation (ETT) are common ICU procedures; however, they can be linked to serious complications. In this case, Gan et al 66 utilized an AR near-enhanced electromagnetic radiation device in older ICU patients undergoing venous puncture reduced the incidence of hematomas; however, it did not shorten the procedure length or reduce the number of attempts required. 66 In conclusion, there is presently no compelling evidence either supporting or opposing the use of AR-assisted venipuncture procedures in patient care. For decades, junior doctors have primarily learned surgical skills through direct exposure to the operating room under the supervision of seasoned surgeons. 67 However, the growing number of trainees and restrictions on resident work hours have limited opportunities for practice. Traditional training methods have become insufficient for mastering advanced surgical techniques, leading to the integration of VR into surgical education. 68 VR simulations provide a highly realistic and interactive learning environment, surpassing traditional methods such as animal models, films, or electronic (e)-learning. These simulations feature intuitive 3D visualizations of anatomical structures, allowing trainees to engage deeply with the anatomy and observe the dynamic changes during each surgical phase. The ability to objectively assess performance through metrics like task completion time, path length, identification of anatomical landmarks, and overall satisfaction enhances the evaluation of psychomotor skills and training effectiveness. 69 In parallel, VR has transformed immersive training within healthcare education. By leveraging educational instruction more engaging and motivating. The development of 360° immersive training films has revolutionized the way pre-clinical disciplines, such as anatomy and physiology, are taught. Learners can now explore blood cells, navigate heart chambers, and examine organs in unprecedented detail, fostering a deeper understanding of complex human anatomy and physiology in a safe and interactive environment. This immersive approach also allows medical students to gain clinical experience from their first year, breaking away from the traditional model where training began in the fourth or fifth year of medical school. 70 Additionally, VR enables medical students to learn the anatomy of sonography by leveraging 3D capabilities to visualize and manipulate sonographic images. This advanced visualization enables students to cut and rotate 3D anatomies, offering a more detailed understanding of anatomical structures compared to 2D images. 71 Institutions like the Toronto Metropolitan University (TMU) Centre for Education in Medical Simulation, in collaboration with High Tech Computer Corporation (HTC), contribute to these innovative tools. 72 VR's capacity to replicate clinical scenarios within a confined space and with minimal setup time allows for seamless integration with other simulation activities, facilitating customization of curricula and generation of extensive performance data. This adaptability supports the incorporation of the latest protocols and ensures that professionals are proficient before engaging with patients. 60 AR further enhances learning opportunities. 73 AR enables students to interact with virtual cadavers, exploring anatomical structures from various angles and providing a more immersive and comprehensive understanding of human anatomy. 74 AR's ability to demonstrate complex relationships between muscles, vessels, and nerves, and observe how these structures are affected by different pathologies, significantly improves the learning experience. This approach overcomes the limitations of traditional cadaver-based studies, offering a richer, more detailed educational experience. 75 AR can also support healthcare professionals in critical care procedures like central line placement. In a controlled trial conducted by Alismail et al 76 with 32 ICU trainees, 15 participants used head-mounted AR glasses during the endotracheal intubation of a training mannequin. The AR display provided repeated guidance on essential procedural steps. Although the AR-assisted group took longer to complete intubation and ventilation, they demonstrated greater adherence to standard best practices for intubation. Hou et al 77 carried out a prospective, controlled pilot study in which nurses without prior experience in neonatal intubation were randomized into either conventional training or AR-assisted training groups. The results indicated that the AR-assisted group required less assistance and reported higher confidence levels following the training compared to those in the conventional training group. A systematic review of 45 trials across various surgical specialties demonstrated that devices like Microsoft HoloLens, STAR, and ImmersiveTouch significantly improved surgical trainee performance compared to traditional techniques, especially when used as supplements to conventional training. Microsoft HoloLens showed promising results in both validity and efficacy, while ImmersiveTouch and STAR exhibited strong validity across all parameters. 78 In conclusion, both VR and AR are thus reshaping surgical education and medical training by providing innovative, effective methods for learning and skill development. VR has become a game-changing tool in healthcare. One of the primary obstacles is ensuring that VR hardware is seamlessly integrated into existing healthcare systems. Compatibility issues between VR headsets and electronic health record (EHR) systems can hinder adoption. 79 For example, VR headsets that are not compatible with hospital EHR infrastructure may be useless. Achieving minimal latency while maintaining visual fidelity is crucial to prevent motion sickness in VR experiences, particularly for surgeons who rely on VR for preoperative planning. AR and VR applications are not intended to replace personal communication and are unlikely to do so. Similarly, while VR-based training offers promising supplementary methods, it cannot replace traditional learning techniques for healthcare providers. To date, there is no substantial evidence supporting the use of AR-assisted procedures, particularly in critical care studies. 67 As technology advances, the challenges associated with virtual reality in healthcare are likely to be mitigated. VR is an endorrhacheal intubation or central venous line placement, in critical care could prolong clinical trial settings. 3 Prolonged use of VR can lead to side effects such as headaches, nausea, and vomiting—commonly referred to as "cybersickness"—which are similar to symptoms of motion sickness. 80 Cybersickness is not yet recognized as a defined health condition. While motion sickness arises from a discrepancy between actual and expected motion, this pathophysiological mechanism may not fully apply to cybersickness. Interestingly, cybersickness may be more pronounced in AR than in VR. In 1 study, 15.3% of participants reported experiencing headaches and 17 other symptoms, including nausea, after using AR-based training for gross anatomy dissection (HoloAnatomy®)

81 ARVR-related side effects appear to differ across various age and gender groups 82 ; an effect is not yet fully understood and warrants further investigation. Consequently, careful patient selection and prompt intervention in case side effects arise could be crucial to the successful application of VR-based technologies. In vulnerable patient groups, such as those who are critically ill, there are ethical concerns surrounding the use of VR/AR technologies. To address this, Kellermeyer et al 83 established 3 core principles: (1) preference for human interaction: where possible, interactions should prioritize human-to-human engagement over human-to-machine interaction, adhering to the principle of "therapeutic alternativism" rather than relying solely on "technological solutionism"; (2) focus on human values: VR technology should be designed with a focus on "critical human values," such as maintaining patient dignity and autonomy, ensuring alignment with "human-oriented value principles"; and (3) patient-centered approach: VR systems should be designed with a primary emphasis on the needs and experiences of patients rather than those of professional users, reflecting a commitment to "patient-centred design". From our point of view, these principles reflect a thoughtful and ethical approach to integrating VR/AR technologies into healthcare. VR/AR should always enhance, rather than replace, the human elements of healthcare, ensuring that both ethically sound and aligned with patient-centred care. Some researchers have suggested establishing a new medical specialty, termed "virtualist." This role would encompass the comprehensive technical and medical training but also a profound understanding of the ethical considerations associated with VR/AR technologies. 84 The integration of VR and AR in healthcare and medical training presents numerous opportunities for advancing patient care and education (refer to Table 1). 85 Future research should focus on expanding the clinical applications of these technologies, particularly in areas such as rehabilitation, pain management, and telemedicine. While current evidence supports the efficacy of VR and AR in reducing stress, managing chronic pain, and improving patient engagement, more high-quality randomized controlled trials are needed to establish long-term outcomes across diverse patient populations.

Summary of the Different Applications of Virtual and Augmented Reality in Healthcare.

[PMC free article] [PubMed] [Google Scholar] 2. Kim M, Jeon C, Kim J. A study on immersion and presence of a portable hand haptic system for immersive virtual reality. Sensors (Basel). 2017;17(5):1141. doi: 10.3390/s1705114 1 [DOI] [PMC free article] [PubMed] [Google Scholar] 3. Bruno RR, Wolff G, Wernly B, et al. Virtual and augmented reality in critical care medicine: the patient's, clinician's, and researcher's perspective. Crit Care. 2022;26(1):326. doi: 10.1186/s13054-022-04202-x [DOI] [PMC free article] [PubMed] [Google Scholar] 4. Eckert M, Volmerg JS, Friedrich CM. Augmented reality in medicine: systematic and bibliographic review. JMIR Mhealth Uhealth. 2019;7(4):e10967. doi: 10.2196/10967 [DOI] [PMC free article] [PubMed] [Google Scholar] 5. Slater M, Sanchez-Vives MV. Enhancing our lives with immersive virtual reality. Front Robot AI. 2016;3:74. doi: 10.3389/frobt.2016.00074 [DOI] [Google Scholar]

distributed compared to physical manuals.[176] Digital instructions increase operator safety by removing the need for operators to look at a screen or manual away from the working area, which can be hazardous. Instead, the instructions are overlaid on the working area.[178][179] The use of AR can increase augmented reality users' feeling of safety when working near high-load industrial machinery by giving operators additional information on a machine's status and safety functions, as well as hazardous areas of the workspace.[178][180] "Augmented reality" redirects here; not to be confused with alternate reality games. "AR games" redirects here. For the Nintendo 3DS game, see AR Games. See also: List of augmented reality games An AR mobile game using a trigger image as fiducial marker The gaming industry embraced AR technology. A number of games were developed for prepared indoor environments, such as AR air hockey, Titans of Space, collaborative combat against virtual enemies, and AR-enhanced pool table games.[181][182][183] The 2004 British game show Bamzooki called upon child contestants to create virtual "Zooks" and watch them compete in a variety of challenges.[184] The show used mixed reality to bring the Zooks to life. The television show ran for four seasons, ending in 2010.[184] The 2003 game show FightBox also called upon contestants to create competitive characters and used mixed reality to allow them to interact.[185] Unlike Bamzooki's generally non-violent challenges, the goal of FightBox was for new contestants to create the strongest fighter to win the competition.[185] In 2009, researchers presented to the International Symposium on Mixed and Augmented Reality (ISMAR) their social product called "Ping", which consisted of a projected screen on a wall.[186] Users could post short text clips or images on the wall and play simple games such as Pong.[186] The BlogWall also featured a poetry mode where it would rearrange the messages it received to form a poem and a polling mode where users could ask others to answer their polls.[186] In 2010, Ogmento became the first AR gaming startup to receive venture capital funding. The company went on to produce early location-based AR games for titles like Paranormal Activity: Sanctuary, NBA: King of the Court, and Halo: King of the Hill. Ogmento's computer vision technology was eventually repackaged and sold to Apple, became a major contribution to ARKit.[187] Augmented reality allows video game players to experience digital game play in a real-world environment. Niantic released the augmented reality mobile game Pokémon Go.[188] Mario Kart Live: Home Circuit is a mixed reality racing game for the Nintendo Switch that was released in October 2020.[16a-Now] The game allows players to use their home as a race track[189] Within the first week of release, 73,918 copies were sold in Japan, making it the country's best selling game of the week.[190] Other research has examined the potential for mixed reality to be applied to theatre, film, and theme parks.[191] Main article: Industrial augmented reality AR allows industrial designers to experience a product's design and operation before completion. Volkswagen has used AR for comparing calculated and actual crash test imagery.[192] AR has been used to visualize and modify car body structure and engine layout. It has also been used to compare digital mock-ups to physical mock-ups to find discrepancies between them.[193][194] See also: Virtual home design software Software allows AR use in visualizing building projects. Computer-generated images of a structure can be superimposed onto a real-life local view of a property before the physical building is constructed there; this was demonstrated publicly by Trimble Navigation in 2004. AR can also be employed within an architect's workspace, rendering animated 3D visualizations of their 2D drawings. Architecture sight-seeing can be enhanced with AR applications, allowing users viewing a building's exterior to virtually see through its walls, viewing its interior objects and layout.[195][196][54] With continual improvements to GPS accuracy, businesses are able to use augmented reality to visualize georeferenced models of construction sites, underground structures, cables and pipes using mobile devices.[197] Augmented reality is applied to present new projects, to solve on-site construction challenges, and to enhance promotional materials.[198] Examples include the Daqri Smart Helmet, an Android-powered hard hat used to create augmented reality for the industrial worker, including visual instructions, real-time alerts, and 3D mapping. Following the Christchurch earthquake, the University of Canterbury released CityViewAR,[199] which enabled city planners and engineers to visualize buildings that had been destroyed.[200] This not only provided planners with tools to reference the previous cityscape, but it also served as a reminder of the magnitude of the resulting devastation, as entire buildings had been demolished. AR has been used to aid archaeological research. By augmenting archaeological features onto the modern landscape, AR allows archaeologists to formulate possible site configurations from extant structures.[201] Computer generated models of ruins, buildings, landscapes or even ancient people have been recycled into early archaeological AR applications.[202][203][204] For example, implementing a system like VITA (Visual Interaction Tool for Archaeology) will allow users to imagine and investigate instant excavation results without leaving their home. Each user can collaborate by mutually "navigating, searching, and viewing data". Hrvoje Benko, a researcher in the computer science department at Columbia University, points out that these particular systems and others like them can provide "3D panoramic images and 3D models of the site itself at different excavation stages" all the while organizing much of the data in a collaborative way that is easy to use. Collaborative AR systems supply multimodal interactions that combine the real world with virtual images of both environments.[205] Main article: Commercial augmented reality AR is used to integrate print and video marketing. Printed marketing material can be designed with certain "trigger" images that, when scanned by an AR-enabled device using image recognition, activate a video version of the promotional material. A major difference between augmented reality and straightforward image recognition is that one can overlay multiple media at the same time in the view screen, such as social media share buttons, the in-page video even audio and 3D objects. Traditional print-only publications are using augmented reality to connect different types of media.[206][207][208][209][210] AR can enhance product previews such as allowing a customer to view what's inside a product's packaging without opening it.[211] AR can also be used as an aid in selecting products from a catalog or through a kiosk. Scanned images of products can activate views of additional content such as customization options and additional images of the product in its use.[212] By 2010, Apple announced Universal Scene Description (USDZ) AR file support for iPhones and iPads with iOS 12. Apple has created an AR QuickLook Gallery that allows people to experience augmented reality through their own Apple device (as of 213) In 2018, Shopify, the Canadian e-commerce company, announced AR Quick Look integration. Their merchants will be able to upload 3D models of their products and their users will be able to tap on the models inside the Safari browser on their iOS devices to view them in their real-world environments.[214] In 2018, Twinkl released a free AR classroom application. Pupils can see how Tom looked over 1,900 years ago.[215] Twinkl launched the first ever multi-player AR game, Little Red[216] and has over 100 free educational models.[217] Augmented reality is becoming more frequently used for online advertising. Retailers offer the ability to upload a picture on their website and "try on" various clothes which are overlaid on the picture. Even further, companies such as Bodymetrics install dressing booths in department stores that offer full-body scanning. These booths render a 3D model of the user, allowing the consumers to view different outfits on themselves without the need of physically changing clothes.[218] For example, JC Penney and Bloomingdale's use "virtual dressing rooms" that allow customers to see themselves in clothes without trying them on.[219] Another store that uses AR to market clothing to its customers is Neiman Marcus.[220] Neiman Marcus offers consumers the ability to see their outfits in a 360-degree view with their "memory mirror".[220] Makeup stores like L'Oreal, Sephora, Charlotte Tilbury, and Rimmel also have apps that utilize AR.[221] These apps allow consumers to see how the makeup will look on them.[221] According to Greg Jones, director of AR and VR at Google, augmented reality is going to "reconnect physical and digital retail".[221] AR technology is also used by furniture retailers such as IKEA, Houzz, and Wayfair.[221][19] These retailers offer apps that allow consumers to view their products in their home prior to purchasing anything.[221][222] In 2017, Ikea announced the Ikea Place app. It contains a catalogue of over 2,000 products—nearly the company's full collection of sofas, armchairs, coffee tables, and storage units which one can place anywhere in a room with their phone.[223] The app made it possible to have 3D and true-to-scale models of furniture in the customer's living space. IKEA realized that their customers are not shopping in stores as often or making direct purchases anymore.[224][225] Shopify's acquisition of Primer, an AR app to scan products and dimension them, allows the retail industry reduce operating costs. Merchants upload product information to the AR system, and consumers can use mobile terminals to search and query the 3D images.[226] An example of an AR code containing a QR code The first description of AR as it is known today was in Virtual Light, the 1994 novel by William Gibson. AR hardware and software for use in fitness includes smart glasses made for biking and running, with performance analytics and map navigation projected onto the user's field of vision,[227] and boxing, martial arts, and tennis, where users remain aware of their physical environment for safety.[228] Fitness-related games and software include Pokémon Go and Jurassic World Alive.[229] Augmented reality systems are used in public safety situations, from super storms to suspects at large. As early as 2009, two articles from Emergency Management discussed AR technology for emergency management. The first was "Augmented Reality—Emerging Technology for Emergency Management", by Gerald Baron.[230] According to Adam Crow, "Technologies like augmented reality (ex: Google Glass) and the growing expectation of the public will continue to force professional emergency managers to radically shift when, where, and how technology is deployed before, during, and after disasters."[231] Another early example was a search aircraft looking for a lost swimmer. Mountain terrain, Augmented reality systems provided aerial camera operators with a geographic awareness of forest road names and locations blended with the camera video. The camera operator was better able to search for the hiker knowing the geographic context of the camera image. Once located, the operator could more efficiently direct rescuers to the hiker's location because the geographic position and reference landmarks were clearly labeled.[232] AR can be used to facilitate social interaction, however, use of an AR headset can inhibit the quality of an interaction between two people if one isn't wearing one if the headset becomes a distraction.[233] Augmented reality also gives users the ability to practice different forms of social interactions with other people in a safe, risk-free environment. Hannes Kauffman, Associate Professor for virtual reality at TU Vienna, says: "In collaborative augmented reality multiple users may access a shared space populated by virtual objects, while remaining grounded in the real world. This technique is particularly powerful for educational purposes when users are collocated and can use natural means of communication (speech, gestures, etc.), but can also be mixed successfully with immersive VR or remote collaboration."[This quote needs a citation] Hannes cites education as a potential use of this technology. One of the first applications of augmented reality was in healthcare, particularly to support the planning, practice, and training of surgical procedures. As far back as 1992, enhancing human performance during surgery was a formally stated objective in developing the first augmented reality systems at U.S. Air Force Laboratories.[1] AR provides surgeons with patient monitoring data in the style of a fighter pilot's heads-up display, and allows patient imaging records, including functional videos, to be accessed and overlaid. Examples include a virtual X-ray view based on prior tomography or on real-time images from ultrasound and confocal microscopy probes,[234] visualizing the position of a tumor in the video of an endoscope,[235] or radiation exposure risks from X-ray imaging devices.[236][237] AR can enhance viewing a fetus inside a mother's womb.[238] Siemens, Karl Storz and IRCAD have developed a system for laparoscopic liver surgery that uses AR to view sub-surface tumors and vessels.[239] AR has been used for cockroach phobia treatment[240] and to reduce the fear of spiders.[241] Patients wearing augmented reality glasses can be reminded to take medications.[242] Augmented reality can be very helpful in the medical field.[243] It could be used to provide vital information to a doctor or surgeon without having them take their eyes off the patient. On 30 April 2015, Microsoft announced the Microsoft HoloLens, their first attempt at augmented reality. The HoloLens is capable of displaying images for laparoscopic surgery.[244] As augmented reality advances, it finds increasing applications in healthcare. Augmented reality and similar computer based-utilities are being used to train medical professionals.[245][246] In healthcare, AR can be used to provide guidance during diagnostic and therapeutic interventions e.g. during surgery. Magee et al.,[247] for instance, describe the use of augmented reality for medical training in simulating ultrasound-guided needle placement. Recently, augmented reality began seeing adoption in neurosurgery, a field that requires heavy amounts of imaging before procedures.[248] Smartglasses can be incorporated into the operating room to aide in surgical procedures; possibly displaying patient data conveniently while organizing precise visual guides for the surgeon.[249][250] Augmented reality headsets like the Microsoft HoloLens have been theorized to allow for efficient sharing of information between doctors, in addition to providing a platform for enhanced training.[251] This can, in some situations (i.e. patient infected with contagious disease), improve doctor safety and reduce PPE use.[252] While mixed reality has lots of potential for enhancing healthcare, it does have some drawbacks too.[250] The technology may never fully integrate into scenarios when a patient is present, as there are ethical concerns surrounding the doctor not being able to see the patient.[250] Mixed reality is also useful for healthcare education. For example, according to a 2022 report from the World Economic Forum, 85% of first-year medical students can Case Western Reserve University reported that mixed reality for teaching anatomy was "equivalent" or "better" than the in-person class.[253] In augmented reality, the student gets a three-dimensional picture of the body that they can interact and perform various actions. Such capabilities are demonstrated by Project Anywhere, developed by a postgraduate student at ETH Zurich, which was dubbed as an "out-of-body experience".[254][255][256] Building on decades of perceptual-motor research in experimental psychology, researchers at the Aviation Research Laboratory of the University of Illinois at Urbana-Champaign used augmented reality in the form of a flight path in the sky to teach flight students how to land an airplane using a flight simulator. An adaptive augmented schedule in which students were shown the augmentation only when they departed from the flight path proved to be a more effective training intervention than a constant schedule.[34][257] Flight students tasked to land in the simulator with the adaptive augmentation learned to land a light aircraft more quickly than students with the same amount of landing training in the simulator but with constant augmentation or without any augmentation.[34] Augmented reality system for soldier ARC4 (U.S. Army 2017) The first fully immersive system was the Virtual Fixtures platform, which was developed in 1992 by Louis Rosenberg at the Armstrong Laboratories of the United States Air Force.[28] It enabled human users to control robots in real-world environments that included real physical objects and 3D virtual overlays ("fixtures") that were added enhance human performance of manipulation tasks. Published studies showed that by introducing virtual objects into the real world, significant performance increases could be achieved by human operators.[258][259][260] An interesting early application of AR occurred when Rockwell International created video map overlays of satellite and orbital debris tracks to aid in space observations at Air Force Maui Optical System. In their 1993 paper "Debris Correlation Using the Rockwell WorldView System" the authors describe the use of map overlays applied to video from space surveillance telescopes. The map overlays indicated the trajectories of various objects in geographic coordinates. This allowed telescope operators to identify satellites, and also to identify and catalog potentially dangerous space debris.[41] Starting in 2003 the US Army integrated the SmartCam3D augmented reality system into the Shadow Unmanned Aerial System to aid sensor operators using telescopic cameras to locate people or points of interest. The system combined fixed geographic information including names, points of interest, airports, and railroads with live video from the camera system. The system offered a "picture in picture" mode that allows it to show a synthetic view of the area surrounding the camera's field of view. This helps solve a problem in which the field of view is so narrow that it excludes important context, as if "looking through a soda straw". The system displays real-time friend/foe/neutral location markers blended with live video, providing the operator with improved situational awareness. Combat reality can be simulated and represented using complex, layered data and visual aides, most of which are head-mounted displays (HMD), which encompass any display technology that can be worn on the user's head.[261] Military training solutions are often built on commercial off-the-shelf (COTS) technologies, such as Improved Performance Research Integration Tool (IPRIT). As of 2018[update], VirTra is being used by both civilian and military law enforcement to train personnel in a variety of scenarios, including active shooter, domestic violence, and military traffic stops.[262][263] In 2017, the U.S. Army was developing the Synthetic Training Environment (STE), a collection of technologies for training purposes that was expected to include mixed reality. As of 2018[update], STE was still in development without a projected completion date. Some recorded goals of STE included enhancing realism and increasing simulation training capabilities and STE availability to other systems.[264] It was claimed that mixed reality environments like STE could reduce training costs,[265][266] such as reducing the amount of ammunition expended during training.[267] In 2018, it was reported that STE would include reconstruction of any part of the world's terrain for training purposes.[268] STE would offer a variety of training opportunities for squad brigade and combat teams, including Stryker, armory, and infantry teams.[269] Researchers at USAF Research Lab (Calhoun, Draper et al.) found an approximately two-fold increase in the speed at which UAV sensor operators found points of interest using this technology.[270] This ability to maintain geographic awareness quantitatively enhances mission efficiency. The system is in use on the US Army RQ-7 Shadow and the MQ-1C Gray Eagle Unmanned Aerial Systems. In combat, AR can serve as a networked communication system that renders useful battlefield data onto a soldier's goggles in real time. From the soldier's viewpoint, people and various objects can be marked with special indicators to warn of potential dangers. Virtual maps and 360° view camera imaging can also be rendered to aid a soldier's navigation and battlefield perspective, and this can be transmitted to military leaders at a remote command center.[271] The combination of 360° view cameras visualization and AR can be used on board combat vehicles and tanks as circular review system.[271] AR can be effective tool for virtually mapping out the 3D topologies of munition storages in the terrain, with the choice of the munitions combination in stacks and distances between them with a visualization of risk areas.[272][unreliable source?] The scope of AR applications also includes visualization of data from embedded munitions monitoring sensors.[272] See also: Automotive navigation system LandForm video map overlay marking runways, road, and buildings during 1999 helicopter flight test The NASA X-38 was flown using a hybrid synthetic vision system that overlaid map data on video to provide enhanced navigation for the spacecraft during flight tests from 1998 to 2002. It used the LandForm software which was useful for times of limited visibility, including an instance when the video camera window frosted over leaving astronauts to rely only on the map overlays.[48] The LandForm software was also first shown at the Army Yuma Proving Ground in 1999. In the photo of right one can see the map superimposed in real world view depicting runways, air traffic control tower, taxiways, and hangars overlaid on video of the scene.[49] AR can augment the effectiveness of navigation devices. Information can be displayed on an automobile's windshield indicating destination directions and meter, weather, terrain, road conditions and traffic information as well as alerts to potential hazards in their path.[273][274][275] Since 2012, a Swiss-based company WayRay has been developing holographic AR navigation systems that use holographic optical elements for projecting all route-related information including directions, important notifications, and points of interest right into the driver's line of sight and far ahead of the vehicle.[276][277] Aboard maritime vessels, AR can allow bridge watch-standers to continuously monitor important information such as a ship's heading and speed while moving throughout the bridge or performing other tasks.[278] In a research project, AR was used to facilitate collaboration among distributed team members via conferences with local and virtual participants. AR tasks included brainstorming and discussion meetings utilizing common visualization via touch screen tables, interactive digital whiteboards, shared design spaces and distributed control rooms.[279][280][281] In industrial environments, augmented reality is proving to have a substantial impact with use cases emerging across all aspect of the product lifecycle, starting from product design and new product introduction (NPI) to manufacturing to service and maintenance, to material handling and distribution. For example, labels were displayed on parts of a system to clarify operating instructions for a mechanic performing maintenance on a system.[282][283] Assembly lines benefited from the usage of AR. In addition to Boeing, BMW and Volkswagen were known for incorporating this technology in assembly lines for monitoring process improvements.[284][285][286] Big machines are difficult to maintain because of their multiple layers or structures. AR permits people to look through the machine as if with an x-ray, pointing them to the problem right away.[287] As AR technology has progressed, the impact of AR in enterprise has grown. In the Harvard Business Review, Magid Abraham and Marco Annunziata discussed how AR devices are now being used to "boost workers' productivity on an array of tasks the first time they're used, even without prior training."[288] They contend that "these technologies increase productivity by making workers more skilled and efficient, and thus have the potential to yield both more economic growth and better jobs."[288] Machine maintenance can also be executed with the help of mixed reality. Larger companies with multiple manufacturing locations and a lot of machinery can use mixed reality to educate and instruct their employees. The machines need regular checkups and have to be adjusted every now and then. These adjustments are mostly done by humans, so employees need to be informed about needed adjustments. By using mixed reality, employees can receive live instructions about the changes. Instructors can operate the representation that every employee sees, and can guide through the production area, zooming in to technical details and explaining every change needed. Employees completing a five-minute training session with such a mixed-reality program have been reading a 50-page training manual.[289] An extension to this environment is the incorporation of live data from operating machinery into the virtual collaborative space and then associated with three dimensional virtual models of the equipment. This enables training and execution of maintenance, operational and safety work processes, which would otherwise be difficult in a live setting, while making use of expertise, no matter their physical location.[290] Product content management has emerged. Most notably, 3-dimensional digital renderings of normally 2-dimensional products have increased reachability and effectiveness of consumer-product education.[291] With augmented reality technology improvements, new forms of interactive product content management have emerged. Most notably, 3-dimensional digital renderings of normally 2-dimensional products have increased reachability and effectiveness of consumer-product education.[291] Augmented reality allows sellers to show the customers how a certain commodity will suit their demands. A seller may demonstrate how a certain product will fit into the homes of the buyer. The buyer with the assistance of the VR can virtually pick the item, spin around and place to their desired points. This improves the buyer's confidence of making a purchase and reduces the number of returns.[293] Architectural firms can allow customers to virtually visit their desired homes. Augmented reality can be used to build mockups that combine physical and digital elements. With the use of simultaneous localization and mapping (SLAM), mockups can interact with the physical world to gain control of more realistic sensory experiences.[294] Like object permanence, which would normally be achievable or extremely difficult to track and analyze without the use of both digital and physical objects.[295] Weather visualizations were the first application of augmented reality in television. It has now become common in weather casting to display full motion video of images captured in real-time from multiple cameras and other imaging devices. Coupled with 3D graphics symbols and mapped to a common virtual geospatial model, these animated visualizations constitute the first true application of AR to TV. AR has become common in sports telecasting. Sports and entertainment venues are provided with see-through and overlay augmentation through tracked camera feeds for enhanced viewing by the audience. Examples include the yellow "first down" line seen in television broadcasts of American football games showing the line the offensive team must cross to receive a first down. AR is also used in association with football and other sporting events to show commercial advertisements overlaid onto the view of the playing area. Sections of rugby fields and cricket pitches also display sponsored images. Swimming telecasts often add a line across the lanes to indicate the position of the current record holder as a race progresses to allow viewers to compare the current race to the best performance. Other examples include hockey puck tracking and annotations of racing car performance[296] and snooker ball trajectories.[119][297] AR has been used to enhance concert and theater performances. For example, artists allow listeners to augment their listening experience by adding their performance to that of other bands/groups of users.[298][299][300] Travelers may use AR to access real-time informational displays regarding a location, its features, and comments or content provided by previous visitors. Advanced AR applications include simulations of historical events, places, and objects rendered into the landscape.[301][302][303] AR applications linked to geographic locations present location information by audio, announcing features of interest at a particular site as they become visible to the user.[304][305][306] AR applications such as Word Lens can interpret the foreign text on signs and menus and, in a user's augmented view, re-display the text in the user's language. Spoken words of a foreign language can be translated and displayed in a user's view as printed subtitles.[307][308][309] It has been suggested that augmented reality may be used in new methods of music production, mixing, control and visualization.[310][311][312][313] Recent advances in mixed-reality technologies have renewed interest in alternative modes of communication for human-robot interaction.[314] Human operators wearing augmented reality headsets such as HoloLens can interact with features. In September 2017, Snapchat announced a feature called "Sky Filters" that will be available on its app. This new feature makes use of augmented reality to alter the look of a picture taken of the sky, much like how users can apply the app's filters to other pictures. Users can choose from a variety of sky styles such as starry night, stormy clouds, beautiful sunsets, and rainbow.[316] Google launched an augmented reality feature for Google Maps on Pixel phones that identifies users' location and places signs and arrows on the device screen to show a user navigation directions.[317] In a paper titled "Death by Pokémon GO", researchers at Purdue University's Krannert School of Management claim the game caused "a disproportionate increase in vehicular crashes and associated vehicular damage, personal injuries, and fatalities in the vicinity of locations, called PokéStops, where users can play the game while driving."[318] Using data from one municipality, the paper extrapolates what that might mean nationwide and concluded that increase in crashes attributable to the introduction of Pokémon GO is 145,632 with an associated increase in the number of injuries of 29,370 and an associated increase in the number of fatalities of 256 over the period of 6 July 2016, through 30 November 2016." The authors extrapolated the cost of those crashes and fatalities at between $2bn and $7.3 billion for the same period. Furthermore, more than one in three surveyed advanced Internet users would like to edit out disturbing elements around them, such as garbage or graffiti.[319] They would like to even modify their surroundings by erasing street signs, billboard ads, and uninteresting shopping windows. Consumers want to use augmented reality glasses to change their surroundings into something that reflects their own personal opinions. Around two in five want to change the way their surroundings look and even how people appear to them. [citation needed] Augmented reality devices that use cameras for 3D tracking or video passthrough depend on the ability of the device to record and analyze the environment in real time. Because of this, there are potential legal concerns over privacy. In June 2024, Meta's collaboration with Ray-Ban on smart glasses faced heightened scrutiny due to significant privacy concerns. A notable incident involved two Harvard students who developed a program named I-XRAY, which utilized the glasses' camera in conjunction with facial recognition software to identify individuals in real-time.[320] According to recent studies, users are especially concerned that augmented reality smart glasses might compromise the privacy of others, potentially causing peers to become uncomfortable or less open during interactions.[321] While recording in the name of public interest, the constant recording of an AR device makes it difficult to do so without also recording outside of the public domain. Legal complications would be found in a situation where a person who is expected or where copyrighted media are displayed. In terms of individual privacy, there exists the ease of access to information that one should not readily possess about a given person. This is accomplished through facial recognition technology. Assuming that AR automatically passes information about persons that the user sees, there could be anything seen from social media, criminal record, and marital status.[322] Ronald Azuma is a scientist and author of works on AR. Jeri Ellsworth headed a research effort for Valve on augmented reality (AR), later taking that research to her own startup CastAR. The company, founded in 2013, eventually shuttered. Later, she created another start-up based on the same technology called Tilt Five, another AR start-up formed by her with the purpose of creating a device for digital board games.[323] Steve Mann formulated an earlier concept of mediated reality in the 1970s and 1980s, using cameras, processors, and display systems to modify visual reality to help people see better (dynamic range management), building computerized welding helmets, as well as "augmediated reality" vision systems for use in everyday life. He is also an advisor to Meta.[324] Dieter Schmalstieg and Daniel Wagner developed a marker tracking systems for mobile phones and PDAs in 2009.[325] Ivan Sutherland invented the first VR head-mounted display at Harvard University.

ARTag – Fiducial marker system Augmented reality-based testing WebAR – Web technology Automotive head-up display – Advanced driver assistance system Bionic contact lens – Proposed device to display information Computer-mediated reality – Ability to manipulate one's perception of reality through the use of a computer Cyborg – Being with both organic and biomechatronic body parts Holography – Recording to reproduce a three-dimensional light field List of augmented reality software Location-based service – General class of computer program-level services that use location data to control systems. Mixed reality – Types of electronic games involving reality and VRPages displaying short descriptions of redirect targets Multimodal interaction – Form of human-machine interaction using multiple modes of input/output Optical head-mounted display – Type of wearable devicePages displaying short descriptions of redirect targets Simulated reality – Concept of a false version of reality Visual reality computer – Telepresence". Archived from the original on 17 July 2022. Retrieved 27 November 2018., Department of Communication, Stanford University. 15 October 1993. ^ Introducing Virtual Environments Archived 21 April 2016 at the Wayback Machine National Center for Supercomputing Applications, University of Illinois. ^ Cipresso, Pietro; Giglioli, Irene Alice Chicchi; Raya, Mariano Alcañiz; Riva, Giuseppe (7 December 2011). "The Past, Present, and Future of Virtual Reality Applications: A Network and Cluster Analysis of the Literature". 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Media related to Augmented reality at Wikimedia Commons Retrieved from "AR is efficient at all stages of surgery, from pre-operative planning to executing and providing post-operative rehabilitation.The technology makes a difference in medical education and training, as well as in explaining to patients their conditions and upcoming procedures.Whether you want to implement AR, VR, XR, or 3D animations, Innovise is as reliable healthcare software development partner that can build even the most complex apps.Instead of relying solely on textbooks or static 2D images, AR allows medical students and doctors in training to interact with detailed 3D models of human anatomy. It's one thing to read about the structure of the heart — it's another to walk around it, zoom in, rotate it, and understand how it works from all angles.Sounds too good to be true? A study published in the Journal of Medical Education and Curricular Development proved that using medical animations improved students' test scores compared to regular books. Now, imagine the impact AR experience may have on the quality of knowledge in medical education. This premise really inspires my colleagues at Innovise to develop quality AR and VR solutions that will help shape practicing doctors of the future.One of the strong examples of augmented reality improves the accuracy of orbital reconstruction surgeries, as well as leads to an 8% increase in patient satisfaction. To me, this research shows that AR isn't here to replace a surgeon's skill but to sharpen it.When speaking about AR surgery planning tools, OpenSight comes to mind. This platform is FDA-cleared and uses Microsoft HoloLens to project diagnostic imaging into the real world. OpenSight is designed for medical settings, enabling surgeons to view 2D, 3D, and even 3D images and plan surgeries accurately.Using AR in medical settings, surgeons overlay detailed 3D models of a patient's anatomy onto a patient's body. They get to see the actual pathology in a real-world environment, and this visual information helps them plan the timing, angles, and sequence of their actions before the surgery.To my mind, the clear benefit of it, compared to scrolling through flat 2D images, is that AR is much more dynamic and visual. For sure, it doesn't magically solve surgical challenges, but it can definitely cut down time to make decisions and improve doctor's situational awareness before the surgery even begins.One study examining the clinical efficiency of such a tool, Verima, caught my eye. Pediatric surgeons in the University Hospital in Bologna used the tool to project holograms of the pathologies on patients before the operations. Doctors participating in the study agreed that 3D visualization substantially improved their ability to interpret pathology dimensions and their relationships with the surrounding organs and vessels.In an operating room, precision is everything, and that's why intraoperative AR navigation feels to me like one of the most natural applications of this technology. AR app displays critical anatomical information and vitals directly onto the surgeon's field of view, helping guide incisions, highlight hidden structures, and minimize potential risks.One of the biggest roadblocks is not the lack of skill, but the lack of "live" contextual information during complex procedures. With augmented reality, medical teams get a live, intuitive guide right in their field of vision instead of relying solely on themselves and the monitors.I saw an inspiring example of this AR application from UC Davis Health, where surgeons are using augmented reality goggles to literally "see through" patients during operations. These AR glasses project 3D models of organs and tissues directly onto the patient's body, allowing for incredibly precise navigation, almost like a GPS for surgery.Physical rehabilitation can be a long, frustrating process, and one of the biggest challenges for doctors is keeping patients motivated and consistent with their exercises. And AR can help with it. For patients, the technology makes rehab programs more interactive, visual, and even fun. Instead of vague instructions like "lift your arm like this," patients can see real-time visual cues, correct their movements instantly, and feel like they're part of a game rather than a medical routine.This level of engagement can make all the difference in recovery speed and long-term outcomes. A meta-analysis published in the Journal of Biomedical Informatics showed that 75% of studies of AR rehabilitation efficiency reported improvements among the respondents. Although AR is not yet poised to replace conventional therapies, this technology is a great complementary tool, especially for remote care interventions.An interesting example of AR for rehabilitation is MirrorAR. It's an AR-based app that captures patients' motions during exercise, detects 16 key joints without any sensors, and displays the core axes of movement to help therapists analyze patients' performance.AR powers remote care assistance and telemedicine and allows experienced medical specialists to virtually "stand" next to a local healthcare provider during a procedure, offering real-time guidance, insights, or step-by-step corrections. This use of AR can change healthcare in rural or underserved areas, enabling access to high-quality expertise. After all, according to the American Medical Association, about 65% of rural areas have a shortage of primary care physicians, so getting a top specialist on-site with AR is much simpler than arranging an in-person visit.One standout example of AR for remote assistance is Proxime, a platform that combines AR, AI, and telepresence to let surgeons collaborate from anywhere in the world. With Proxime, a remote surgeon can see exactly what the on-site surgeon sees, annotate directly into their field of vision, and guide procedures as if they were right there in the operating room. A clinical study of the tool found that in VOKA. It's a 3D atlas of normal anatomy and pathology, offering a hyper-realistic and interactive learning experience. What stands out to me is the VOKA AR mode: users can project 3D models into their real-world environment, making study sessions feel almost like hands-on dissections. You are welcome to check out the full article I wrote about this breakthrough project a few years back, or explore the video demo below to understand how the app works and what it brings.With AR tools, surgeons can now carefully study detailed, patient-specific anatomy models created using images like CT scans or MRIs. Not only does it help them plan the surgeries and navigate complex anatomy during minimally invasive operations, but improves clinical accuracy of each move.While some members of the medical community may be skeptical about this technology, its efficiency has been proven. For instance, one study found that using mixed reality improves the accuracy of orbital reconstruction surgeries, as well as leads to an 8% increase in patient satisfaction. To me, this research shows that AR isn't here to replace a surgeon's skill but to sharpen it.When speaking about AR surgery planning tools, OpenSight comes to mind. This platform is FDA-cleared and uses Microsoft HoloLens to project diagnostic imaging into the real world. OpenSight is designed for medical settings, enabling surgeons to view 2D, 3D, and even 3D images and plan surgeries accurately.Using AR in medical settings, surgeons detailed 3D models of a patient's anatomy onto a patient's body. 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With Proxime, a remote surgeon can see exactly what the on-site surgeon sees, annotate directly into their field of vision, and guide procedures as if they were right there in the operating room. A clinical study of the tool found that AR telementoring platform helps build medical competency safely in advanced-level surgical trainees performing complex procedures, like radical prostatectomy. "Many of Innovise's in-house MD consultants I talk to are truly excited about the opportunities AR opens for medical education — if only these tools existed when they were stuck with anatomy books! That's why our team is passionate about building these AR solutions, combining our deep knowledge of 3D visualization and doctors' hands-on medical expertise.' Senior Technical Delivery Manager in Healthcare and MedTechIn critical situations, there's no time to hesitate or second-guess; that's why AR-based emergency response training software is such a powerful tool. It creates realistic, high-pressure environments where responders can practice dealing with emergency scenarios, saving time and reducing deadly risk. This kind of immersive learning doesn't come from traditional textbooks or practice; it builds muscle memory, sharpens critical thinking, and prepares care teams for real-world chaos.An interesting example — although powered by VR, not AR — is Oxford Medical Simulation. Designed for training, it recreates lifelike emergency scenarios, say, cardiac arrests or anaphylactic incidents, and learners must react fast and make decisions under pressure. What I think is great about Oxford Medical Simulation is that it not only tests clinical knowledge but also communication and teamwork, which are absolutely crucial in emergencies.When it comes to AR healthcare assistants, the sky is the limit. The technology can power anything from smart hospital navigation to interactive doctor onboarding assistants. And could you imagine using AR, say, for patients learning wound care at home? They could get clear, step-by-step AR guidance right when and where they need it.To my mind, this kind of contextual, visual assistance dramatically lowers the anxiety and frustration, meaning patients and staff can focus more on doing the task, without worrying if they understood instructions correctly. And it's not just an idea, AR virtual assistants are already here. For instance, the Code Cart AR app is designed to train healthcare workers on the proper use of emergency code carts, offering hands-on learning opportunities.Seeing how medical AR eases surgery, rehabilitation, and diagnostics, it's clear to me that it's only picking up steam. Improving clinical accuracy, enhancing medical training, expanding access to expert care — the clients I worked with cites these benefits of AR among the most prominent ones. So, if you're considering AR for your healthcare organization or a HealthTech product, now is the time to act.At Innowise, my team and I have had the privilege of working on both AR solutions and complex healthcare projects for years. We know from practice the challenges that come with building technology for real-world medical environments, and learned to find practical workarounds. If you're looking into healthcare AR software development, we're here to help. Portfolio Manager in Healthcare and Medical Technologies Share — copy and redistribute the material in any medium or format for any purpose, even commercially. Adapt — remix, transform, and build upon the material for any purpose, even commercially. The licensor cannot revoke these freedoms as long as you follow the license terms. Attribution — You must give appropriate credit , provide a link to the license, and indicate if changes were made . You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use. ShareAlike — If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original. No additional restrictions — You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits. You do not have to comply with the license for elements of the public domain or where your use is permitted by an applicable exception or limitation . No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. Build Your Own Telehealth in 10 Minutes Oops! We could not locate your form. Augmented reality (AR) is not limited to the gaming arena. Technology is creating gigantic waves in healthcare. Yes, you heard it right! AR in Healthcare has created a future of limitless possibilities. The world of AR, with goofy-looking headgear and sci-fi detours, is ready to transform patient medical experiences. The next generation will make more distinguished advances, and we can expect more meaningful AR experiences. As a healthcare organization, you'd want to know everything about the thriving technology. We got you. In this blog, we will be looking at some of the most significant AR use cases in healthcare. Let's dive in! Advancements in Augmented Reality—Critical Insights Before we look at some of the promising insights of augmented reality in the medical field, here are some crucial facts: According to Gartner, 5G mobile network technology represents an opportunity to accelerate the adoption of AR. (Source) Gartner conducted a 3D enterprise survey. The study highlights that AR/VR applications of 5G attract the biggest expectations and are driven by new revenue across all use cases and respondents. (Source) According to Forrester, by 2021, AR will be commonplace, while VR remains niche. (Source) According to Zion Market Research, the Global Healthcare AR/VR market will reach USD 5,115 Million By 2025. The estimate will be at a CAGR of around 29.2% between 2019 and 2025. (Source) Another critical insight that experts highlight is that the AR market will grow into an 18 billion USD valuation by 2023. (Source) Here's a quick sneak peek at the AR/VR market size. Source It is quite evident that augmented journeys are essential. The critical question is—what does it mean for your healthcare organization? How will you benefit from the augmented reality journey? Let's find out. Opportunities for Augmented Reality in Healthcare The new applications for AR in the healthcare sector can enhance patient care. How? First, AR can help doctors diagnose and treat patients. Accessing to real-time patient data, they can perform functions better than before. Also Read: Developing a Healthcare App in 2024: What Do Patients Really Want? The novel ways of AR in the healthcare industry are groundbreaking. Let's check out some of the new opportunities. 1. Augmented Surgery Imagine the power of AR—surgeons visualize the bones and internal organs of patients without having to cut open a body. Now, that's great, isn't it? Surgeons can get access to real-time, life-saving patient information. They can now use this data during complicated or straightforward procedures. How? Surgeons can use AR to study their patients' anatomy. They can enter their MRI data and CT scans into an AR headset. Then, overlay specific patient anatomy on top of their body before going into surgery. The process will help surgeons to visualize muscles, bones, and internal organs. You're right without losing sight of the patient.With AR, surgeons can perform accurate and low-risk surgeries, saving time. Scenario: Surgeons and doctors at hospitals like Imperial College and St. Mary's Hospital in London have begun using Microsoft's HoloLens AR glasses during reconstructive surgery on patients who have suffered severe injuries. Startups in Augmented Surgery Let's look at some of the promising startups in the augmented surgery arena. Table 1. Startups in Augmented Surgery Startup Features BioFlightVR (- Offers VR/AR doctor training and 360° enhanced videos - AR/VR medical training module helps students and doctors refine their learning and increase retention. EchoPixel (- Uses medical imaging devices, helping physicians with displays of a 3D model, using CT images of a patient's abdomen - EchoPixel True 3D AR product uses medical image datasets, enabling medical professionals to get an accurate diagnosis. Medical Realities (- Offers medical training products, specializing in VR and AR - Medical procedures can be viewable on the Oculus Rift 2. Augmented Diagnosis You must have observed that some patients find it challenging to describe their symptoms to doctors accurately. Now, with AR, patients will be able to express their symptoms better. The process will make it easier for doctors to determine their patients' symptoms and accurately diagnose them. Scenario: Imagine a patient coming to a doctor for a necessary shot. The nurse can now use AR to find veins easily. How? Using AccuVein, an AR startup that uses a handheld scanner, nurses can determine where the veins are. Startups in Augmented Diagnostics Let's look at some of the promising startups in the augmented diagnostics arena. Table 2. Startups in Augmented Diagnostics Startup Features Orca Health's EyeDecide (- The app can simulate the impact of specific conditions on a person's vision AccuVein (- Uses AR and a handheld scanner that projects over the skin and shows nurses and doctors where veins are in the patients' bodies Augmedix (- Cuts down on administrative work - A technology-enabled documentation service where physicians don't have to check their computers during patient visits and generate medical notes in real-time SentiAR (- Helps transform the experience in interventional procedures using real-time holography of the patient's anatomy and catheter location Atheer (- Helped establish AR (Augmented interactive Reality) computing - AiR Smartglasses integrates hand tracking and gesture control with their see-through display, enabling users to interact using familiar gestures, voice commands, and motion tracking. Meta (company)) - Assists doctors and surgeons with patient information and data with a total AR experience 3. Augmented Practice What happens when medical students make mistakes in a real-life procedure? You're right! It would be disastrous. However, learning in the dissection lab and real-life methods is essential. Now, that's where AR can be revolutionary in the field of medicine and education. Medical institutions are beginning to implement AR into their curriculum to provide students with valuable hands-on learning experiences. With AR in education, it would be easy to simulate patient and surgical encounters for students. AR technologies can allow medical students to visualize and practice theories during their training. Scenario: Using AR apps, students can check out the overlay anatomy data on a 3D human skeleton. The visualization would help them to understand better how the human body works. Startups in Augmented Practice Let's look at some of the promising startups in the augmented practice arena. Table 3. Startups in Augmented Practice Startup Features ImmersiveTouch (- Provides hi-tech solutions in training and education using VR/AR - Offers comprehensive education solutions, including next-generation surgical simulators and learning management systems Touch Surgery (- Allows users to practice surgery irrespective of time and place - Disseminates the best techniques and procedures to improve the quality of operation worldwide As you can see, there's an enormous opportunity for the healthcare industry with innovative new AR products and applications. As forward-thinking healthcare providers, you need to investigate the use cases that are most suitable for your businesses. Practical Use Cases of AR in Healthcare AR applications in healthcare aren't limited to AR glasses. Today, Physicians are using AR very effectively during interventional procedures. Examples include Computerized Tomography (CT) and Magnetic Resonance Imaging (MRI) visualization paths. You would also find AR used increasingly in medical education. So, the possibilities are limitless, fun, and exciting. Let's explore some significant real-life use cases of how AR apps are improving the patient's medical experience. 1. Augmented Reality Showing Defibrillators Nearby and Saving Lives Picture this—you have a relative next to you who collapses suddenly. What would you do? Yes, after controlling the rush of emotions, you'd wish to reach out to someone. You may think of calling a doctor, an ambulance, or your friends for help. Here's an interesting option. You can consider downloading the Layar mobile browser combined with AED4EU app to your phone next to the basic emergency numbers. If you get into a similar situation, then you will be able to help more. Lucien Engelen, who worked at the Radboud University Nijmegen Medical Centre, created the AED4EU, which can add places where automated external defibrillators or AEDs are located. The great part—physicians can access the database through the new application. You can project the exact location of the nearest AEDs on the screen of your phone with the Layar browser. Next, it would take less than a few minutes to find them and also help the ones in need. 2. Virtual Collaboration Between Physicians With AR What if the primary surgeon is miles away? AR can come to your rescue. If the primary surgeon is away, and a specialist on hand has possession of AR tools, then the professional can follow instructions and help. Doctors can use AR with collaborative surgeries, and even have effective meetings on any medical issue with AR video conferencing. It could be a life-saving moment with specialists located far away from the clinic helping out. 3. Google Glass Can Help Guide New Mothers with Breastfeeding Google Glass can help mothers struggling with breastfeeding get some expert help. Melbourne-based innovation company Small World conducted a Google Glass trial with the Australian Breastfeeding Association. In the trial, telephone counselors could see through the eyes of mothers while they breastfed at home. The insights could help struggling mothers get expert help throughout the day. The best part—the mothers didn't have to put down their babies from their arms. 4. Augmented Reality in Surgery Surgeries used to have a high mortality rate. Now, with AR, procedures can be much safer than before. AR can assist doctors and specialists, providing them with all the necessary information when trying to save patients' lives. As physicians operate, they can be more aware of organ location, meshes of the vein, and diagnosis reports appearing right in front of their eyes. Here's an example of how Brazilian surgeons implemented AR virtual interfaces that assisted them in spinal surgery. Source The technology can undoubtedly help to minimize risks. Moreover, it will help to reduce physical processes dramatically. 5. Augmented Reality Can Help Patients to Describe Their Symptoms Better An accurate diagnosis needs symptoms detailed accurately. You may have observed that patients quite often struggle with describing their symptoms. Such situations could lead to an erroneous diagnosis. Let's look at AR in Ophthalmology; the technology could help with patient education. EyeDecide, a medical app, uses the camera display to stimulate the impact of specific conditions on a person's vision. Apps like EyeDecide doctors can use to make a simulation of the vision of a patient suffering from a specific condition. So, patients can understand their symptoms and their actual medical state for scenarios such as Cataracts or AMD. When patients comprehend the long-term effects of their lifestyle on their health, there is a greater possibility of them making positive changes. 6. AR Can Help Nurses Find Veins Easily AccuVein, a start-up firm, is using AR, which is helping both nurses and patients. How? Most IVs (intravenous injections) typically miss the vein on the first stick. The situation worsens for children and the elderly. Now, AccuVein uses augmented reality by using a handheld scanner that projects over the skin and shows nurses and physicians where veins are in the patients' bodies. According to Vinny Luciano, AccuVein's marketing specialist, technology has been used on more than 10 million patients. The AR app helps with finding a vein on the first stick 3.5x more likely. Imagine studying some boring and indecipherable drug descriptions. It doesn't sound exciting, isn't it? Although it would have been fun to know how a drug works in your body. How can you explore the world of pills and also have fun? Augmented Reality is your answer. Patients can now see how the drug works in 3D. With the help of AR, patients can explore how drugs work. Lab workers could also monitor their experiments with AR equipment. 8. HoloLens Can Help With the Study of Anatomy Wouldn't it be nice to visualize the human body in an easy and explorative way? Now, that's a reality! Case Western Reserve University and the Cleveland Clinic have partnered with Microsoft and released a HoloLens app. The app is called HoloAnatomy, and it helps to visualize the human body in a simple-and-spectacular way. The HoloLens Headset from Microsoft can help app users see everything from muscles to the smallest veins on a dynamic holographic model. Such apps can revolutionize medical education shortly, as students would be able to visualize the human body in great detail. 9. Helping Kids Learn About the Human Body The UK-based company Curiscope developed the Virtuali-tee T-shirt. The company is popular for creating immersive learning experiences. So, what about a T-shirt? Why would kids love it? Here's the thing—you can see the inner parts of the human body through realistic holograms. Virtuali-tee brings anatomy to life, making it fun and exciting for kids to explore the human body. As you can see, you already have plenty of examples of AR in healthcare. Augmented reality will continue to generate value for healthcare organizations and improve patient care. It's up to you to discover new business processes and explore how AR can help you improve your systems. If you are overwhelmed, then you can always reach out to an expert developer, such as Imaginovation, who can help you with crafting a meaningful AR journey for your organization. Time to Plan Your Augmented Reality Journey As a forward-thinking entrepreneur, you will need to take some critical steps to set up or integrate AR in your systems-and-processes. You can brainstorm with your team to ensure a smooth transition by thinking about how and where to integrate your existing technologies with AR. You can also streamline the apps that you want to use and train and re-skill your employees properly. A word of caution—with the use of AR, you will also need to plan steps to ensure the security of patient data. With wearables, there could be data privacy issues, and you would need to have a detailed plan for security. Finally, get ready to explore the exciting world of augmented reality. Choose apps that can help you improve the patient's medical experience and enjoy streamlining your healthcare processes. Craft a Meaningful Augmented Reality Journey with Imaginovation If you want to craft a meaningful AR journey that can improve patient medical experiences or elevate user engagement, we can help. Explore our expertise in Augmented Reality Mobile App Development to see how we can bring your vision to life. We are an award-winning web and mobile app development company with vast experience in crafting remarkable digital success stories for diverse companies. Let's talk.

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