**Review**

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# The medical metaverse in China: Current applications and future prospects

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**SUMMARY**: The medical metaverse, with its potential for efficient care delivery, improved patient outcomes, and reduced healthcare costs, is profoundly impacting global healthcare systems. Scholars researching this topic primarily focus on exploring specific scenarios for its use. This article aims to analyze the development trajectory, potential applications, and directions for management optimization within the medical metaverse. Through a case study of China, we review the current status of use of the medical metaverse and systematically examine its future prospects and challenges. We contend that the medical metaverse offers significant value in enabling equitable distribution of healthcare resources, enhancing medical care efficiency, promoting the integration of medical education, research, and clinical practice, and assisting in public health management. To ensure sustainable development, however, the imperative task is to proactively devise technical standards and legal regulatory frameworks and to dynamically monitor the effectiveness of medical metaverse technologies, with the ultimate aim of maximizing the value of the medical metaverse.

***Keywords***: medical metaverse, current uses, prospects, challenges, China

## 1. Introduction

The digital healthcare revolution is poised to create new opportunities for global health (*1*), addressing the escalating demand for care, the inequitable distribution of resources, and the urgent need for more efficient and resilient healthcare models (*2*). Within this transformative landscape, the metaverse, an emergent paradigm integrating technologies such as extended reality, artificial intelligence, blockchain, cloud computing, and digital twins, is progressively demonstrating its profound potential to reshape healthcare delivery and management (*3,4*). The metaverse's intrinsic characteristics are immersion, persistence, and decentralization. These offer innovative solutions to many persistent challenges in conventional healthcare. Such issues include geographical limitations, high training costs, and suboptimal patient experiences (*5*).

A global consensus on the medical metaverse concept has not yet been established (*6*). A multidisciplinary expert group, consisting of physicians and IT specialists from Asia, the United States, and Europe, published the *Expert Consensus on the Metaverse in Medicine* (*7*). Metaverse in medicine is considered to be the medical Internet of things implemented through augmented reality technology in this consensus (*8*). In this space, doctors, patients, medical devices, and data interact *via* avatars. This facilitates a wide range of medical activities, including remote diagnosis and treatment, medical training, simulated surgery, and health management. Currently, various countries are actively exploring pathways for use of the metaverse in healthcare. The United States (*9*) and Europe (*10*) lead in areas like product approval and setting data standards. Meanwhile, Asian nations, exemplified by South Korea (*11*) , Japan (*12*), and China (*13*), are proactively advancing pilot projects. This is often under strategic government guidance. However, global challenges persist. These include technological immaturity, data privacy concerns, and ethical issues. This is driven by pressing challenges: an aging population, a heavy burden of chronic diseases, and unequal distribution of medical resources.

While its practical applications are not yet fully mature, its development model offers unique research value. Existing research primarily focuses on the medical metaverse's potential (*14-16*) or uses related to specific diseases (*17*). However, most studies are limited to describing scenarios for use of a single technology. They thus lack systematic integration (*18*). Moreover, policy research is still highly limited. The unique Chinese policy environment, and particularly its role in driving or constraining metaverse development in healthcare, has not been adequately discussed. This study therefore aims to address these critical gaps. We will utilize a systematic analytical framework covering policy, technology, and applications. This framework will comprehensively assess China's medical metaverse. It will evaluate its policy-driven mechanisms, current uses of technology, core scenarios, and key future development trends. The ultimate goal is to maximize the value of the medical metaverse in China.

## 2. Current uses of the medical metaverse in China

### 2.1. Policy support for the medical metaverse

#### 2.1.1. National strategic guidance

The Chinese Government highly prioritizes both the digital economy and national health. It has successively issued key documents, including the Healthy China 2030 Planning Outline (*19*) and the 14th Five-Year Plan for Digital Economy Development (*20*). Their aim is to profoundly advance the integration of digital technology and healthcare. The 14th Five-Year Plan for Digital Economy Development explicitly promotes the integrated application of virtual reality (VR) and similar technologies. It also supports the innovative use of metaverse-related technologies within the medical sector. Moreover, the State Council outlined a strategic plan to accelerate metaverse development in its Three-Year Action Plan for Metaverse Industry Innovation and Development (2023–2025) (*21*). This plan focuses on key areas that include technological innovation, industrial applications, governance frameworks, and infrastructure development.

Key areas of support for the medical metaverse include: *i*) Digital Twins and Precision Medicine: Promoting the use of digital twin technology in clinical research, disease simulation, and personalized treatment. *ii*) Immersive Medical Training: Encouraging medical facilities to utilize VR or augmented reality (AR) technology. This involves creating virtual operating rooms and medical education environments. The aim is to enhance the training quality of healthcare professionals. *iii*) Smart Telemedicine: Supporting the development of remote diagnosis, virtual doctors, and AI medical assistants. These advances are based on metaverse technologies that aim to improve healthcare accessibility in remote areas. *iv*) Data Security and Privacy Protection: Formulating robust data security and privacy protection frameworks. This ensures that patient information is secure within the medical metaverse environment.

#### 2.1.2. Regional support policies

Under national strategic guidance, local governments have actively responded (*22*) . They have successively issued industrial support policies. These policies prioritize "metaverse + healthcare" as a key direction of development (*23*). Local support policies are categorized into different phases based on differences in the timing of policy issuance and the frequency with which they are cited. Regional support policies are characterized by initial deployment in economically developed Eastern cities. This forms medical metaverse industrial clusters.

Different regions possess varying industrial structures. Consequently, their specific support approaches differ (*24*) . Some regions have incorporated the medical metaverse into their development plans. Examples include Shanghai's Action Plan for Cultivating New Metaverse Tracks (2022–2025) and Fujian Province's Three-Year Action Plan for Metaverse Industry Innovation and Development (2023–2025). Other regions are building medical metaverse industrial bases and ecological parks. For instance, Zhejiang Province's Digital Economy Development Leading Group Office issued the Guiding Opinions on the Construction of Future Industry Pilot Zones in Zhejiang Province. Some regions also implement measures to support the medical metaverse ecosystem. An example is Beijing's Eight Measures on Accelerating Innovation-led Development of the Metaverse in the Beijing Urban Sub-center. These policies explicitly support specific scenarios for use, such as remote diagnosis, virtual surgery, and intelligent monitoring. They also encourage collaborative innovation among medical facilities, technology companies, and universities. This fosters technological research, development, and practical application (*25*).

#### 2.1.3. Industry standards

The National Health Commission actively promotes "Smart Hospital" and "Internet + Healthcare" projects. Similarly, the National Administration of Traditional Chinese Medicine and the National Administration of Disease Control and Prevention have developed relevant guidelines, such as the Reference Guide on Scenarios for Use of Artificial Intelligence in the Healthcare Sector. Though not explicitly mentioning metaverse technology, these policies' core requirements align closely with the medical metaverse. They encourage technologies like 5G, the Internet of things (IoT), and VR/AR to optimize diagnostic, treatment, and care models. Examples include remote surgical guidance and 3D digital imaging archives. These policies collectively remove obstacles for deployment of metaverse technology in hospital settings. They also provide clear entry points for its use.

### 2.2. Technological progress in the medical metaverse

#### 2.2.1. Core driving technologies

The development of China's medical metaverse relies on a multi-dimensional technological ecosystem.

This ecosystem integrates core technologies, digital infrastructure, interactive terminals, and a foundation. Its progress stems not from a single technological breakthrough, but from the innovation and integration of multiple technology clusters (*26*). Figure 1 illustrates the overall technical architecture of the medical metaverse. It emphasizes how foundational technologies support upper-layer applications. The definitions of these technologies, along with their digitalization processes, have been thoroughly explored in similar studies (*27,28*).

Unlike conventional communication technologies, the medical metaverse relies on a core cluster of technologies. These include extended reality, digital twins, and blockchain (*29*). Extended reality (XR), VR, AR, and mixed reality (MR) bridge the gap between virtual and physical worlds. VR creates fully immersive virtual environments through computer-simulated visuals and audio *via* head-mounted devices (*30*). Its key features are immersion, interactivity, and imagination. VR plays a vital role in medical education, psychotherapy, and rehabilitation. AR overlays virtual information onto real-world scenes using localization algorithms (*31*). It is characterized by presence, augmentation, and relevance. AR is widely used in remote surgical guidance, intraoperative navigation, and patient education. MR combines VR's immersion with AR's overlay capabilities for extensive interaction of the virtual world and real world (*32*) . Its features include presence, blending, and realism. MR is utilized in drug discovery and expert virtual consultations. Digital twin technology uses sensors to gather real-world data, digitizing it to create corresponding virtual models. Researchers develop human digital twin models from physical data for medical diagnosis and assessment. Blockchain technology provides data security and privacy protection for the medical metaverse. It uses distributed ledgers and cryptographic algorithms to ensure secure storage of and authorized access to medical data. Blockchain also creates unique digital identities. This prevents identity fraud and data tampering while enhancing system transparency and efficiency.

Support from infrastructure like the IoT and 5G/6G networks is crucial (*33*). They ensure real-time transmission of massive data between terminals and cloud servers. This guarantees smooth immersive experiences and synchronized remote operations. Interactive terminals, such as wearables and digital tools like 3D modeling, provide direct user experiences within the medical metaverse. Notably, existing digital healthcare systems also form a foundational basis for metaverse development (*34*). Mature telemedicine platforms, for instance, have resolved issues with cross-regional medical collaboration. Their established communication standards and workflows lay the groundwork for more immersive metaverse consultations. Digital hospitals and smart wards enable administrators to simulate and optimize resource allocation, personnel flow, and infection control within the metaverse (*35*). These systems serve as early forms of the metaverse. They also provide gathering of crucial data, process validation, and user education for its full-scale development.

### 2.2.2. Technology landscape

Building on foundational technological breakthroughs, China's medical metaverse technology ecosystem is steadily expanding, as detailed in Table 1. Leading Chinese companies, including Tencent, Huawei, and

Real-World Information

| Application Layer | R&D | Prevention | Diagnosis | Treatment & Rehabilitation | Education & Innovation | Industrial Applications |
|---|---|---|---|---|---|---|
| Tool Layer | Modeling Tools | Rendering Tools | Development Engines | Interaction Tools | Peripheral Tools | Virtual Asset Tools |
| Data Layer | Data Acquisition | Data Transmission | Data Storage | Data Analysis | Data Processing | Data Validation |
| Perception Layer | Visual: Extended Reality Devices | Auditory: Speech Recognition Systems | Haptic: Somatosensory & Wearable Devices | Olfactory: IoT Sensors | Neural Devices: Brain-Computer Interface | Virtual Humans, Bionic Robots |
| Hardware Layer | Hardware Components | Computing | Communication Networks | Operating Systems | Technologies | |
| Foundation Layer | Chips | Cloud Computing | 5G | Desktop OS | AI Technology | Blockchain Technology |
| | Sensors | Edge Computing | 6G | Mobile OS | IoT Technology | XR Technology |
| | Optical Components | Spatial Computing | WiFi | Server OS | Web3.0 | Digital Twin |

Policies, Regulations, and Standards

**Figure 1. Technical architecture of the medical metaverse.** The figure details its layered technical architecture, from the foundation to applications. It includes hardware, data, tools, and specific medical use cases. This illustrates the metaverse's comprehensive strategy for technological integration and healthcare innovation.

**Table 1. Uses of core technologies in the medical metaverse in China***

| Technology layer | Core technology | Key players | Key devices | Areas of use |
|---|---|---|---|---|
| Foundation layer | Chips | Huawei, Cambricon, Sugon | Domestic GPU/ASIC chips | Medical AI computing, Image processing |
| | Cloud/Edge computing | Alibaba Cloud, Tencent Cloud, Huawei Cloud | Medical cloud servers, Edge nodes | Imaging cloud platforms, Remote surgery |
| Hardware layer | XR devices | Huawei, Pico, DPVR | AR/VR headsets, Holographic devices | Surgical navigation, Medical education |
| | BCI | Zhejiang Univ., Tsinghua Univ. | EEG signal devices | Neuro-rehabilitation, Consciousness disorder treatment |
| | Medical wearables | Huami Tech, Yuwell Medical | Smart bands, Vital sign monitors | Chronic disease management, Post-operative monitoring |
| Data layer | Medical big data | National Health Medical Big Data Center, Ping An Health | Federated learning, Blockchain systems | EHR sharing, Epidemic prediction |
| | Privacy computing | Ant Group, WeBank | MPC frameworks | Cross-institutional data collaboration, Privacy protection |
| Tool layer | Digital twin modeling | Siemens Healthineers, United-Imaging | Unity/Unreal, Medical imaging software | Organ 3D reconstruction, Surgical simulation |
| | Virtual surgery engine | Dmicoda, Weishu Zhiyuan | VR surgical planners, Mechanics simulators | Surgical training, Surgical plan rehearsal |
| | AI-assisted diagnostic tools | Infervision, Deepwise | Imaging AI platforms | Lung cancer screening, Fundus lesion identification |
| Application layer | Prevention | Ping An Good Doctor, DXY.cn | VR fitness devices, Health apps | Virtual health communities, Disease prevention education |
| | Diagnosis | Tencent Health, Ali Health | AI+VR imaging systems | Early tumor diagnosis, Remote imaging consultation |
| | Treatment & rehabilitation | Beijing Xuanwu Hospital, Shanghai Ruijin Hospital | VR therapy pods, BCI rehab devices | Anxiety treatment, Parkinson's rehabilitation |
| | Medical education | Shanghai Jiao Tong Univ., West China Hospital | VR anatomy labs, Surgical simulators | Medical student skill training, Clinical operation assessment |
| | Medical innovation | Baidu, WuXi AppTec | Virtual drug lab platforms | Molecular structure simulation, AI-assisted drug design |

******Data Sources*: *Metaverse Development Research Report 3.0* (2022). Metaverse Culture Lab, Tsinghua University; *Global and China Metaverse Industry Analysis Report* (2023). Huajing Research Institute.
*Abbreviation*: XR: extended reality; AI: artificial intelligence; VR: virtual reality; GPU: graphics processing unit; ASIC: application-specific integrated circuit; EHR: Electronic Health Record; EEG: Electroencephalography; MPC: multi-party computation; BCI: brain-computer interface; Tech: technology; Univ: university.
*Note*: The entities listed are illustrative examples of active participants in the development of medical metaverse technologies in China, identified from public sources. Their inclusion does not indicate endorsement or commercial affiliation. The authors declare no conflicts of interest.

Alibaba, are at the forefront of technological research and development, and implementation of applications. Uses of different technologies involve tiered characteristics. For instance, technologies such as remote diagnosis and virtual medical education have been used on a large scale. They demonstrate significant social value and are now core scenarios within the medical metaverse. Scenarios for use of AI+XR diagnostics and intelligent monitoring are continuously expanding. Technologies such as medical non-fungible tokens and brain-computer interfaces remain in the early exploratory stages. They hold immense potential but face numerous challenges. Other technologies, including hardware devices and blockchain data sharing, are mature in their application. However, they require further upgrading and optimization.

### 2.3. Typical scenarios for use of the medical metaverse

The healthcare ecosystem involves diverse participants, including patients, clinicians, practitioners, government, academia, and industry. Thus, uses of the medical metaverse span the entire gamut of healthcare. They range from R&D, prevention, diagnosis, treatment, and rehabilitation to education and innovation. This promotes collaborative healthcare development (*15,36,37*), as shown in Figure 2.

*A. Drug development and clinical translation*: Metaverse technology accelerates drug screening and clinical trials. For instance, simulating drug-target

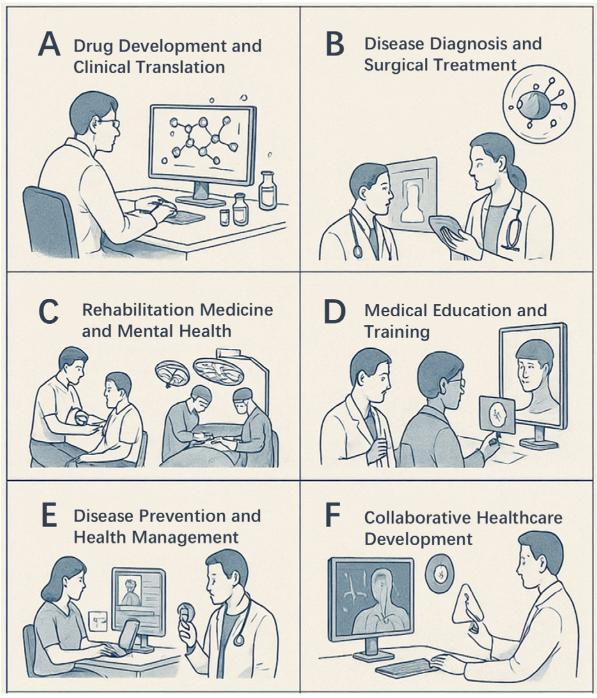


**Figure 2. Typical scenarios for use of the medical metaverse.** The figure illustrates the metaverse's innovative uses in drug R&D, surgery, diagnosis, and treatment, rehabilitation, medical education, and patient monitoring, highlighting the extensive integration of virtual technology into healthcare.

interactions significantly reduces early drug discovery cycles (*38*). A cutting-edge direction combines brain-computer interfaces with VR for clinical translation. In 2020, Zhejiang University completed a clinical translation study of China's first implanted BCI (*39*). A high-level quadriplegic patient successfully controlled a virtual arm in a VR environment *via* thought and then manipulated an external robotic arm for complex 3D movements.

*B. Disease diagnosis and surgical treatment*: Medical diagnosis and treatment represent the most impactful area for use of the medical metaverse. Its core value lies in making invisible lesions and anatomical structures visible and interactive (*40,41*) . In 2019, Jin *et al.* (*42*) proposed the Holographic Digital Human. This concept involves using 100 ZB of medical data to build full diagnostic and treatment process models, aiming to upgrade care systems. A Zhongshan Hospital team at Fudan University conducted lung cancer screening *via* the IoT (*43*). Their auxiliary application, PNapp5A, uses cloud computing for deep analysis, intelligent assessment, and management of lung nodules. This significantly reduces the healthcare system burden (*44*). A Beijing Chang Gung Hospital team, affiliated with Tsinghua University, used AR for intraoperative simulations and guidance in complex neurosurgery. This enabled surgeons to clearly visualize deep structures during lesion removal, effectively avoiding damage to critical functional areas (*45*). Research has shown that VR-assisted planning for pancreatic cancer surgery achieved 100% treatment accuracy and sensitivity compared to conventional 2D imaging planning. Average intraoperative blood loss was also effectively controlled (*46*).

*C. Rehabilitation medicine and mental health*: The metaverse can aid patients in receiving contextual and behavioral information. Its immersive quality offers unparalleled advantages for rehabilitation and psychotherapy compared to conventional methods. A meta-analysis on post-stroke upper limb dysfunction showed that, at the 6-month long-term follow-up, the motor function scores of the VR therapy group improved significantly more compared to the conventional rehabilitation group (mean improvement of 3.9 *vs.* 1.5 points, $p$=0.045) (*47*). The Shanghai Mental Health Center, a leading Chinese facility, has incorporated VR exposure therapy into routine clinical practice. It independently developed a series of virtual scenarios for specific phobias (*48,49*). Examples include simulated public speaking, virtual elevators, and high-rise edges.

*D. Medical education and training*: The metaverse marks a significant milestone in medical education. It is addressing the challenges of the high risk and high cost of practical medical instruction. In 2022, Yang *et al.* (*50*) developed a virtual training project for rigorous closed chest drainage in clinical nursing. This project integrates theoretical learning, human-computer interaction, and intelligent assessment. It effectively enhances nurses' technical skills, critical thinking, and emergency response capabilities. Shanghai Jiao Tong University's School of Medicine created an oral and maxillofacial surgery simulation training system. By creating personal digital twin training profiles for each trainee, it enabled personalized and precise training. Data have shown that trainees who used this system had a more standardized technique and better understanding of complex anatomical structures, effectively reducing the time to transition from a novice to a qualified surgeon (*51*).

*E. Disease prevention and health management*: The medical metaverse brings significant benefits to individual health management and broader public health governance. He's team applied the XGBoost algorithm to EHR and wearable device data (*52*). They created an electronic frailty index to predict frailty risk and adverse event rates in elderly patients during and after hospitalization. This allows a shift from passive treatment to proactive prevention. A comparative study on uses of VR health education indicated significant improvements (*53*). Users of VR had 22% higher comprehension scores and a nearly 30% higher retention rate a week later compared to a 2D video control group. They also reported significantly higher intent to be vaccinated, demonstrating vast potential for promoting healthy behaviors.

*F. Collaborative healthcare development*: Both international and domestic regional healthcare development currently face resource imbalances. The medical metaverse, through its remote presence, data integration, and immersive collaboration features, is overcoming geographical barriers. It promotes a more equitable and efficient collaborative healthcare ecosystem. In 2021, Professor Ye's team at Huazhong University of Science and Technology's Tongji Medical College successfully conducted three remote consultation surgeries for frontline soldiers and border residents, respectively located 3,600 km and 4,500 km away, using MR cloud platform technology (*54*). The average network latency during the entire remote collaborative process was below 30 ms, fully meeting real-time surgical requirements, with no complications observed.

## 3. Prospects for medical metaverse development in China

### 3.1. Prospects for use

Global statistics indicate the metaverse's global healthcare market was valued at \$5.06 billion in 2021. It is projected to reach \$ 71.97 billion by 2030, with a compound annual growth rate (CAGR) of 34.8% during the forecast period (2022–2030) (*55*). China's initial exploration in medical metaverse policy, technology, and scenarios for use suggests the trajectory for its future development is already emerging.

3.1.1. Balancing healthcare resource allocation

China urgently needs medical metaverse support. This is due to highly concentrated and regionally imbalanced quality healthcare resources. Remote collaborative surgical networks are essential to achieving equitable access to premium medical resources (*56*). In the future, a mature medical metaverse could foster a collaborative healthcare system. Oncology, imaging, and pathology experts from different countries could conduct synchronized consultations. They could jointly manipulate a patient's 3D digital twin model. This would enable collaborative development of optimal treatment plans (*57*). Expert digital humans, trained on vast high-quality diagnostic and treatment data, could continuously provide standardized, expert-level auxiliary diagnostic advice to doctors on the ground. This would greatly enhance the homogenization of local medical care. This represents not just a technological extension, but a reshaping of healthcare equity.

3.1.2. Enhancing healthcare efficiency

Metaverse technology will drive healthcare transformation from passive treatment to proactive health management. The core lies in a comprehensive improvement of efficiency and personalization. Individual digital models will integrate all patient data, from genomics, lifestyle, and environmental exposure to medical history. These models will dynamically simulate health trajectories. They could precisely predict major disease risks, such as cardiovascular disease and diabetes, years in advance. They will also simulate the long-term impact of various interventions on health. This will truly provide predictive and preventive medicine (*58*). To some extent, it can alleviate China's dual challenges of the chronic disease burden and an aging population.

3.1.3. Promoting integrated medical education, research, and practice

Current challenges in China's healthcare system include difficulty promoting quality core technologies. There are also long training cycles for large-scale elite personnel and limited translation of clinical research. The metaverse holds the promise of bridging clinical practice, education, and research (*59*). An iterative metaverse medical education, research, and practice platform is envisioned. Experts could perform complex surgeries, with all operative processes — from minute instrument movements to critical decision points — anonymously recorded. These data could be instantly fed to teaching and research platforms, significantly reducing the clinic-to-lab-to-clinic translation cycle.

3.1.4. Assisting public health decision-making

China faces severe challenges due to its massive population base, high-density urban clusters, and increasing openness. Conventional public health emergency response systems are becoming insufficient. The medical metaverse can provide city-level, and even national-level, public health digital twin systems (*60*). Specifically, three functions can be performed: *i*) Real-time monitoring: Viral transmission hotspots, population mobility trends, and real-time utilization of medical resources can be depicted in 3D. *ii*) Precise prediction: Simulations can assess the potential impact of various interventions. This allows selection of strategies with the lowest socio-economic cost and optimal effectiveness. *iii*) Efficient command: Wearable devices can deliver visualized, precise instructions to frontline personnel. Those devices can also acquire real-time feedback. This will enable a new model of prediction, precise decision-making, and efficient collaborative governance.

3.2. Development challenges

The metaverse integrates numerous advanced technologies. It holds immense potential across medical diagnosis, treatment, rehabilitation, and education. It promises an unprecedented smart healthcare ecosystem, capable of accelerating self-evolution and knowledge iteration. However, this profound paradigm shift also introduces new ethical, governance, and social challenges (*61*).

The first is the technological cost. Effectively transforming existing healthcare systems with the metaverse requires robust hardware. This includes specialized glasses, sensors, and other devices to accurately ascertain a patient's condition. However, such equipment is costly (*62*). Moreover, the metaverse demands high-level connectivity for efficient operation. This results in massive infrastructure costs for providers. It places significant financial demands on healthcare administrators.

The second challenge is technical bottlenecks. Healthcare interactions between patients and doctors, or patients and treatment resources, are frequent and complex. This leads to immense volumes of data stored and transmitted within the metaverse. It also lowers the sensitive threshold for network latency. Computing power demands will consequently surge (*63*). In-depth research on and use of edge computing, distributed systems, and blockchain technology are potential solutions to this issue.

The third challenge is the cognitive divide. As an emerging technological paradigm, the medical metaverse differs significantly from conventional healthcare models in its operational logic and methods of interaction. This leads to clear disparities in acceptance and ability to use technology among doctors and patients. The cognitive divide is essentially a challenge of cultural adaptation to the digital transformation of healthcare practices. Research indicates that level of education, years in the profession, income, and social norms all influence acceptance (*64*).

The fourth challenge is data privacy and security. The medical metaverse collects and extensively shares sensitive patient data, including EEG, biometrics, and health preferences. This raises significant data privacy and surveillance concerns (*65*). Existing policies primarily promote industry growth, offering only principle-based statements on risks like data sovereignty and virtual medical liability. Actionable details on implementation are lacking. Consequently, addressing emergent risks, such as XR medical accidents or BCI ethical disputes, may lead to regulatory evasion and delayed emergency responses.

### 3.3. Directions for policy optimization

Rapidly developing due to policy and innovation, the medical metaverse optimizes healthcare but also introduces risks. While strong in resource integration, current policies need enhanced technical security, cross-border data flow, and ethical frameworks. An updated governance framework is thus essential, following historical expansions seen with EHRs (*66*) and online services (*67*).

Technologically, top-level design must embed security and privacy. Scholars suggest minimal privilege access (*68*) and biometric blockchain authentication for data protection (*69*). Ethically, dedicated committees should set clear standards for digital human doctors, affective computing, and immersive therapies. Policy adaptation involves revising existing laws. For example, specific metaverse clauses under China's Personal Information Protection Law could allow blockchain-encrypted cross-border research data, similar to EU digital health strategies for data classification and whitelisting.

Cross-departmental collaboration is crucial. Key regulators (the National Health Commission, MIIT, and CAC) must come together on implementation, data governance, and industry standards. Joint innovation hub selection, offering limited policy exemptions for data sharing and new care models, is one example. Formulating joint emergency plans for novel risks like XR accidents or data breaches clarifies responsibilities and ensures consistent R&D, clinical use, and compliance.

A dynamic evaluation system enhances governance and manages market expectations given rapid metaverse expansion. The Gartner hype cycle can assess technical maturity, guiding differentiated policies (*70,71*). In terms of its value, a quantifiable system, based on scenario maturity, clinical need, market potential, and ethical risks, should identify high-value, sustainable uses, ensuring evidence-based decisions (*72*).

## 4. Conclusion

The development of China's medical metaverse is characterized by policy-driven growth, technological integration, and scenario innovation. Under the national "14th Five-Year Plan for Digital Economy" and "Healthy China 2030" strategies, local governments actively issue specific support policies. These policies drive the use of core technologies like XR, AI, and 5G. This includes scenarios such as drug R&D, remote diagnosis, surgical treatment, medical education, and intelligent monitoring.

Despite ongoing challenges in computing power bottlenecks, data privacy, and cognitive divides, the medical metaverse holds great future value. This can be realized through cross-departmental collaboration. Such cooperation will jointly advance technical standardization, legal and ethical regulation, and dynamic scientific evaluation. The metaverse is expected to enhance healthcare accessibility, precision, inclusiveness, and equity. This will provide a valuable reference for global digital healthcare development.

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