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Beyond Your Sight Using Metaverse Immersive Vision With Technology Behaviour Model

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ABSTRACT

With the advancement of technology, the metaverse image is used to improve the success rate of surgical. The purpose of this study was to understand the acceptance of extended reality surgery by different populations of medical experts and patients. The main reason for using a triangular mixed model for the study is because of the small amount of relevant research data for this study, quantitative research, exploratory research, and cross-sectional research can avoid some human interference and reduce error. The results of the study data showed that the image model, interaction design, surgeon, and clarity of use of the head-mounted display with metaverse technology by the expert group were conducive to improved surgical success rates. Metaverse surgery offers opportunities for modern digital surgery and can effectively improve the expert's ability to promote the smoothness of physical indicators during the procedure. This study is pioneering the role of a metaverse in facilitating surgery from the dual perspective of medical experts and patients.

KEYWORDS

Extended Reality, Hyper Visual, Imaging, Immersive, Metaverse, Technology Behavior Model

1. INTRODUCTION

Metaverse is a concept based on extended reality technology beyond the universe, a three-dimensional space of virtual reality parallel to reality (Bibri & Allam, 2022; Mystakidis, 2022). In the field of medical imaging, digital transformation has a profound impact on image processing analysis of structural images of the human body and realistic contexts (Zhang et al., 2022). Extended Reality

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(XR) technology is a new technology combined with Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR)(Sugimoto, 2022). Virtual reality technology enables virtual surgery, which can be used for students to simulate and predict problems that arise during surgery, by virtually constructing models of human structures and performing surgical simulations (Boedecker et al., 2021; Pringle et al., 2022). Augmented reality technology enables the construction of 3D graphics based on physical images by overlaying virtual objects with multiple images and digitization (Kaplan et al., 2021). both VR and AR are virtual behavioural representations of an indirect representation of the real world. XR is a computer-formed virtual and real environment that can be combined to make the environment more realistic and believable (Alizadehsalehi et al., 2020). It enables people to observe more intuitively the three-dimensional relationship between the tissues and organs, blood vessels and nerves inside the human body, as well as the complex movement of muscle tissue and microbial movement (Alizadehsalehi & Yitmen, 2021; Andrews et al., 2019; Beams et al., 2022).

The use of head-mounted displays (HMDs) in interventional procedures uses virtual technology of extended reality combined with human medical image data (figure 1) to create a model that fits the patient's actual condition (Nakamatsu et al., 2022; Ong et al., 2021). It can better help surgical experts in pre-surgical protocol design and surgical planning (Sadeghi et al., 2022). On the other hand, it facilitates the patient's preoperative information and understanding (Arpaia et al., 2022). The head-mounted display enables surgical experts to share images and videos, while teaching and communicating with remote and real-time guidance and assistance. In research by Verhey, et al. (Verhey et al., 2020), using Microsoft HoloLens for open orthopaedic surgery, experimental results showed a significant increase in contrast perception, as well as a reduction in operative work time and increased operational efficiency. In spinal medicine research, the use of intelligent technology can effectively improve the performance of data acquisition, communication, and access (Sommer et al., 2022). In particular, telemedicine requires extremely high CT resolution, high-definition cameras, high-performance da-ta network transmission (Patil & Kumar, 2019), editable holograms (Velazco-Garcia et al., 2021), and HMDs to allow easy viewing of content in real-time to make timely and accurate diagnoses and decisions (Diaka et al., 2021). The high performance of digital transformation provides the feasibility of using intelligent technology in surgery, further expanding the use of metaverse, XR in clinical surgery(Tan, 2022).

Figure 1.
Head-mounted displays surgery

The issue of trust between the doctor and the patient before surgery is often one of the main issues for the patient in choosing a surgeon for surgery (Romare et al., 2021). How improve the trust between patients and doctors is an urgent issue that needs to be resolved. The use of HMDs enables an immersive experience of the surgical procedure, allowing patients to gain insight into the surgical plan as well as the risks and feel safe enough (Zagury-Orly, 2022). At the same time metaverse technology can relieve patients' anxiety and relax their bodies to minds through the landscape of sound and soft music (Pittig et al., 2021). Especially for pediatric cardiac surgery, children are more fearful of surgery than adults due to their young age, and excessive anxiety will increase the patient's intraoperative risk (Gold et al., 2021).

This study investigated the value of the metaverse in clinical surgery through subjective perceptions of the differences between XR technology and conventional surgery from both the surgical expert and patient perspectives. The Technology Behavioral model of the technique proposed by Gong and Joseph was used. A triangulated mixed research approach and questionnaires for different target populations were used. The main reason is that there is less information about metaverse medical care and a single research method cannot satisfy the two-way study of this research. A PLS-SEM statistical method was used to conduct a multi-structured, multi-level cross-sectional analysis of the collected data. A systematic analysis of the internal and external structure of each variable allowed for a more comprehensive mixed study. First, the hypotheses of this study were formulated based on the available relevant in-formation and literature to establish the theoretical framework. Second, a questionnaire was prepared to collect data for the study. The results were derived by computing the collected data using Smart PLS software. Finally, the present study was summarized including the contributions and research conclusions. Surgical experts and patients are generally more willing to accept and use metaverse surgery, which can effectively improve the efficiency and success rate of surgery and make it safer. conference.

2. LITERATURE REVIEW

The immersive experience of the metaverse is receiving significant attention from medical fields such as surgery, and related applications are being developed(Koo, 2021). The metaverse medical field, particularly in surgery, will have huge application space in the future(El-Sabbagh, 2021). In particular, it is used for preoperative simulation in neurosurgery and vascular surgery, as well as for customization of surgical plans(Gagandeep et al., 2021; Iop et al., 2022). With the metaverse platform, through the integration of images, doctors can "see" beyond the real details of the surgery itself and can "look" at the structure of nerves and blood vessels from multiple angles of anatomical space(Dadario et al., 2021; Herur-Raman et al., 2021). According to the findings of a Future Doctor White Paper(2022) published by Elsevier on March 30, 2022, digital information technology will be deeply integrated with healthcare in the next decade, and digital medical technology will provide important support for healthcare professionals' treatment decisions. On the other hand, diversified medical scenarios pose new challenges to healthcare capabilities. Along with the deep integration of digital technology and medical means and the overall improvement of patient's health literacy, diversified medical and health service models can provide convenience for doctors and patients and improve the efficiency of diagnosis and treatment(Diaka et al., 2021; Kim & Choi, 2021; Simone et al., 2021).

2.1 Metaverse 3D Medical Imaging

The metaverse is a virtual reality environment through a combination of decentralization and 3D holographic imaging. Through 2D images of medical testing image instruments CT, and MRI, the 2D image data is generated by the computer into a segmentable 3D image that associates the real presence of the user(Boedecker et al., 2021). Colour markers, manipulation and 360-degree multiple image segmentation on their images are realized. The meta-universe technology with augmented reality found in Kye's research allows medical students and novices to explore the human body structure for deconstruction experiments(Kye et al., 2021). For spine surgery, the metaverse enables the construction of 3D images of the spine visualization, allowing experts to differentiate, localize and simulate the surgery of nerves, blood vessels, bone marrow centres and related soft tissue structures(Garavand & Aslani, 2022). It is also useful to simulate and practice the technical difficulties associated with surgery. It effectively improves the surgical technique and operation specification. The use of metaverse 3D images is more detailed and precise for surgical experts using 2D images.

2.2 Metaverse Virtual Surgery

Metaverse Virtual Surgery, instead of being a kind of video incoming like VR games, is a highly realistic visual technology that recreates an operating room scene for people such as interns, surgeons, and medical device Experts who are in a VR environment, allowing users to exercise the actual operation of various types of surgery in a virtual environment through wearable devices(Kostov & Wolfartsberger, n.d.; Levy et al., 2021; Yamazaki et al., 2021). A study by Tu et al., that uses HoloLens 2 to provide doctors with an enhanced and accurate 3D video view, is specially designed to equip neurosurgeons with adjustable, zoomable eyes(Tu et al., 2021). This enhanced 3D hologram view allows surgeons to effectively see through the skull and brain tissue to the inside of the patient's brain, helping surgeons to see tumour details directly during surgery(Oteri et al., 2021). Recently, in Brazil, a pair of cranially conjoined twins were separated, based on the exploration of multiple separations performed by experts in metaverse technology, and the 3D modelling and printing technology was used to build a precise anatomical structure, model the brain, skull, and blood, and create a cutting and separation plan to complete the surgery(McCallum, 2022). In AppliedVR's immersive therapy, the combination of VR and AR provides patients with treatment plans for pre-and post-operative anxiety management, postpartum health, and pain management, guiding users to follow sound frequencies and visualized breathing rhythms in an immersive environment to practice and address mental health and emotional well-being issues(Chong et al., 2021; Fanini et al., 2021).

2.3 Metaverse X Medical

As virtual reality and augmented reality (VR/AR), technologies continue to enhance there will be disruptive changes, especially for medical surveillance(Yang et al., 2022). Expanded Reality Healthcare Transformation is a holographic delivery, mixed reality platform that brings digital connections to life and provides new ways to teach, learn, and virtually perform tasks remotely(Catalano et al., 2022; Steike et al., 2022; Wang, Ning, Li et al, 2022). Collaborative iterations in a shared virtual space. Surgeons can digitally perform complex brain procedures in virtual reality. It is a holographic delivery, mixed reality platform that brings digital connections to life and offers new ways to teach, learn and perform tasks virtually at a distance(Garavand & Aslani, 2022). Surgical Operating Room Technology - Enables surgeons to digitally perform complex brain procedures in virtual reality(Huh, 2022). The ability to communicate with patients and perform preoperative visualization using head-mounted displays allows patients to experience a more friendly and safe procedure while enhancing patient trust in the surgeon and reducing patient anxiety. Enhancing the telemedicine experience through AR/VR still makes their medical experience more patient-friendly and safe(Mozumder et al., 2022).

3. FRAMEWORK MODEL

3.1 Technology Behaviour Model

The theoretical model used in this case makes the Technology Behavior Model, which is formed with the Technology Acceptance Model (TAM)(Yuen et al., 2020) and the Theory of Planned Behavior (TPB) (Ajzen, 2020)change. This model was developed in Gong and JosephNg's study of the value of extended reality glasses for clinical procedures (Gong & JosephNg, 2022). The results show that the model is people's mindset and acceptance of new things, technologies, and the recognition of new technologies and surgical methods through the Theory of Planned Behavior of Sensory Awareness (Liu, 2022). The change of behavioural consciousness is given from the choice of subjective will to the effect of use. It confirms the increase in the efficiency of people's acceptance of new things itself and the subjective behavioural changes of individuals. Objective response to people's recognition and strong willing-ness to accept the use. A single TAM, when it comes to the impact of new technologies, has an error of 30-40% (Ng & Gong, 2022), and these errors are caused by focusing on the mutual causality between variables. TPB is a good remedy to the TAM system for the change in the individual's consciousness to the inner thoughts of the person in the process of behaviour selection. The study is conducted on both external and internal factors for the new technology. So in this recognition process for surgical experts and patients, on the one hand, the effectiveness of the new technology is experienced through use, and on the other hand, the desire of the user to use the new technology is identified. Therefore, namely the Technology Behavior Model (TBM), was applied to this study.

3.2 Determinants

This study was divided into two parts due to the different target populations (namely the medical expert ad the patient that will undergo the surgical operation). Different questions about influencing factors were asked of surgical experts and patients.

3.2.1 Hyper Visual Expert Usefulness (HVEU)

Hyper Visual Expert Usefulness refers to the ability of surgical experts to effectively improve surgical success rates through the use of Extended Reality Metaverse technology HMDs. Extended Reality technology has holograms that can be modelled in 3D (Gong et al., 2021). The use of multi-interaction technologies, especially vision and haptics, helps the surgical expert to operate with greater precision. HVEU is mainly based on digital to visual 360 image display in surgery (Jaeschke et al., 2022), combined with medical images to achieve actual tissue images of different patients. It is suitable for remote real-world transmission, voice communication, visual manipulation, and haptic sensing, facilitating better than traditional surgical operations (Cofano et al., 2021; Kwok & Koh, 2020). In addition, it can prompt and supervise surgical experts in the order of instrumentation and surgical instrument use. The use of HD cameras allows for clear recording of surgical images, facilitating documentation and improving visual clarity (Banfi & Mandelli, 2021). These suggest that the extended reality metaverse for the surgical specialist can improve the success rate of surgery (Beams et al., 2022). Hence, the proposed hypothesis is:

Hypothesis 1 (H1): HVEU has a positive impact on surgical experts' intention to use the metaverse for surgery.

3.2.2 Hyper Visual Expert Ease of Use (HVEEU)

Hyper Visual Expert Ease of Use (HVEEU) is a way for surgical experts to save time and surgical costs by using extended implementation technology that enables easy operational access (Al-Sabbag et al., 2020). This suggests that users are effective in using new technologies to improve efficiency and can subjectively change their original decision-making methods and embrace the use of new technologies (Alfadda & Mahdi, 2021). This change in pay-for-use behaviour is a concrete manifestation of perceived ease of use (Unal & Uzun, 2020). Existing studies have shown that medical monitors can avoid multiple visual instrument views in their daily work, facilitate access to images, and facilitate concentration (Vasilevski & Birt, 2020). Using HMDs in surgery, the surgical expert can feel the importance of technology to the success of the procedure (Schuermans et al., 2022). This leads to subjective changes in user behaviour. Hence, the proposed hypothesis is:

Hypothesis 2 (H2): HVEEU has a positive impact on surgical experts' intention to use the metaverse for surgery.
Hypothesis 3 (H3): HVEEU has a positive impact on the HVEU.

3.2.3 Image Modeling (IM)

Image modelling is the digitization of medical images into holograms by computer. Medical holograms enable 3D imaging of medical images of the whole body of differ-ent patients. It can achieve a three-dimensional overlap with the human body, facilitating the identification and localization of the patient's tissues and organs, blood movement, and nerves by surgical Experts (Dadario et al., 2021; Frost et al., 2020; Mikami et al., 2022). This reflects the usefulness of image modelling and the ability to quickly find and identify images more quickly and easily than existing methods, showing the ease of use of the new technology (Jang et al., 2021). In tumour surgery and neuro-interventional procedures, there is often an intricacy of vessels and nerves that require more precise separation (Abou El-Seoud et al., 2019; Wilfredo López-Ojeda, 2022). Improvements in imaging have a positive impact on the choice of surgical experts for metaverse procedures. Hence, the proposed hypothesis is:

Hypothesis 4 (H4): IM has a positive impact on the use of metaverse surgery XRU by surgical Experts.
Hypothesis 5 (H5): IM has a positive impact on the use of metaverse surgery HVEEU by surgical Experts.

3.2.4 Interaction Design (ID)

Interaction design refers to interaction techniques that extended reality to include the six senses of sight, touch, hearing, taste, smell, and sixth sense track (Turrado et al., 2021). The operating room is a sterile and special environment where surgical experts need to operate by mouse or keyboard during surgery and will be cross-contaminated (Rutkowski et al., 2021). The use of voice and eye interaction facilitates the liberation of hands. Also, voice interaction in remote surgery is beneficial for experts to communicate. Secondly, haptic interaction is beneficial to the haptic perception of the expert during surgery, especially in the process of tumour removal, for the peeling of the tumour edge environment (Poux et al., 2020). With the enhancement and use of these interactive technologies, the surgical expert can better achieve the completion of the surgery and facilitate the operation. In teaching, virtual surgery helps surgeons to learn and simulate surgical practice (Tang et al., 2020) and to develop surgical plans for formal surgery. Hence, the proposed hypothesis is:

Hypothesis 6 (H6): ID has a positive impact on the use of metaverse surgical XRU by surgical Experts.
Hypothesis 7 (H7): ID has a positive impact on the use of metaverse surgery HVEEU by surgical Experts.

3.2.5 Operation Norm (ON)

The operation specification is an extended reality technology that can display the steps of using the relevant instrument on the monitor by voice or text transmission, which can facilitate the correct operation of the instrument by the user (Parsons et al., 2020). Secondly, the images can be digitally transformed and superimposed to generate high-definition stereoscopic images that can be easily viewed by the user's eyes, allowing the surgical specialist's vision to focus on the hand operation and avoiding excess autogenous movements such as body rotation (Ye et al., 2022). The standardized operation of the surgical specialist helps to avoid operation errors of the surgical specialist during the surgery (Hu et al., 2021). The actual operation enables monitoring the standardization of the operator's surgical procedure and improves the effective success rate of the operation (Koo, 2021). On the other hand, human organs move through heartbeat and respiration, and the discovery of the regularity of this movement facilitates the precise matching of surgical experts in surgery and reduces errors. Hence, the proposed hypothesis is:

Hypothesis 8 (H8): ON has a positive effect on the use of metaverse surgery XRU by surgical Experts.
Hypothesis 9 (H9): ON has a positive effect on the use of metaverse surgery HVEEU by medical Experts.

3.2.6 Usage Perspicuity (UP)

Usage Perspicuity means that the metaverse surgery to perform the procedure can replace the human eye (Han & Leite, 2022). The head-mounted display is equipped with a high-definition camera with microscope technology that enhances the visual range of the human eye by zooming in. It can also be connected to an internal lens to transmit internal images to the monitor in high definition (Flotyński, 2020) and can be recorded in real-time. Existing surgical procedures require the use of bulky instruments to assist the surgical specialist in examining the inside of the body, and image transmission is based on 2D technology, which does not allow for the construction of 3D images (Bai et al., 2021). The use of ex-tended reality tracking technology allows for real-time tracking of the image location while looking inside, making it easier for the surgical specialist to locate and mark (Ge et al., 2022). This actual alteration of the visual senses facilitates the simplified identification of lesion conditions. Behavioural changes alter the operator's habits of use. Hence, the pro-posed hypothesis is:

Hypothesis 9 (H9): UP has a positive effect on the use of metaverse surgical XRU by surgical Experts.
Hypothesis 10 (H10): UP has a positive effect on the use of metaverse surgery HVEEU by surgical Experts.

3.2.7 Hyper Visual Patient Attitude (HVPA)

Hyper Visual Patient Attitude is the subjective behaviour of users toward new things and technologies (Shmueli, 2021). This attitude change is due to, the recognition of the knowledge of new things, and emotional tendencies (Fan et al., 2021). Preoperatively, the surgeon has to communicate with the patient and the patient's family to inform them about preoperative precautions and surgical risks. Through head-mounted displays, patients can more easily understand the procedure in the form of virtual surgery and surgical video images, and through virtual surgery simulation, it is possible to perceive the impact of surgical data transfer into three-dimensional images, and the clarity of the view during surgery for the operation (Palaniappan et al., 2022). It is also possible to relieve patients' anxiety by listening to music, and videos. Hence, the proposed hypothesis is:

Hypothesis 12 (H12): HVPA contributes to the recognition of the patient's metaverse surgery.
Hypothesis 13 (H13): HVPA contributes to the HVPU of metaverse surgery.

3.2.8 Hyper Visual Patient Usefulness (HVPU)

Hyper Visual Patient Usefulness refers to the ability of patients to be able to perceive their improvement in surgical success through the use of metaverse technology (Alfadda & Mahdi, 2021). The surgical simulation allows for a more in-depth experience of the surgeon's procedure, as well as the risks involved in the surgery and how to deal with them (Jang et al., 2021). The clarity of the doctor's visual image can be perceived through the first view. All of this has the potential to improve patient confidence in the surgery and thus change the patient's choice of surgery. Hence, the proposed hypothesis is:

Hypothesis 14 (H14): HVPU contributes to patient acceptance of metaverse surgery.
Hypothesis 15 (H15): HVPU has a positive effect on changing patients' behavioural attitudes.

3.2.9 Operation Value (OV)

Operational value refers to the value of surgery performed with ex-tended reality technology. As seen in the actual operational use by surgeons, XR technology can be simulated and practised before surgery to anticipate the risks that exist during surgery and facilitate the performance of difficult surgeries (Allison et al., 2020; Wilfredo López-Ojeda, 2022). Intraoperative use of interaction allows for remote communication, random image finding, improved human eye vision, and supervision of the surgical procedure by the surgical specialist. These performance improvements can be experienced through the patient's perception of its use and combined with the doctor's communication enhance the patient's recognition of the use of high-tech technology in surgery. The ease of use of the new technology for surgery is perceived through a before and after comparison of surgical timeliness (Southworth, Silva, & Silva, 2020). Thus, facilitating the conversion of the patient's subjective consciousness, the acceptance of XR technology for surgery is positively influenced. Hence, the proposed hypothesis is:

Hypothesis 16 (H16): OV has a positive effect on patients' behavioural attitudes towards choosing metaverse surgery.

3.2.10 Operation Rick (OR)

Operational risk refers to the risks involved in clinical surgical treatment (Schuermans et al., 2022). Surgical risk usually refers to the risks present in surgery, which can be either technical or some unknown problems (Ivanov et al., 2021). But technical risks can be solved by using high technology. In the case of conjoined twins' separation, the data is converted into images by scanning the instruments to form a 3D hologram (Gehrsitz et al., 2021). Multiple preoperative simulations are practised using metaverse virtual surgery to ensure that the foreseeable problems of surgical separation are fully addressed, and the risks of surgery are reduced (Klinker et al., 2020). On the other hand, there are also operational errors caused by surgical experts due to the time of surgery, and the high tension of nerves and any mistake in front of life is a possibility of a crisis of life. The extended reality system can avoid the operator's unconscious operational errors by recording the original data and re-minding the expert of the correct treatment during the surgery (Lareyre et al., 2021). These patients can perceive the effect of surgery and change their behavioural choices by using the experience before surgery. Hence, the proposed hypothesis is:

Hypothesis 17 (H17): OR has a positive effect on patients' behavioural attitudes towards choosing metaverse surgery.

3.2.11 Trust (TR)

Trust refers to the responsibility of one person for a promise given by another person under specific conditions (Romare et al., 2021). The patient's trust in the extended reality procedure depends on the physician (Perin et al., 2021). This trust is indirect or passive and is judged through the physician's use of technology to complete the surgical complaint and in-fluence the patient's decision. Patient acceptance is influenced by both technology and physician use (Du et al., 2020). In cases where the use occurs, the enhancement of patient trust in the technology is carried out by the active user and also increases the patient's trust in the physician (Gopichandran & Sakthivel, 2021). The positive impact of the technology on the procedure is a subjective behavioural change in the patient's use of the technology. Hence, the proposed hypothesis is:

Hypothesis 18 (H18): TR has a positive effect on patients' behavioural attitudes towards choosing metaverse surgery.

3.2.12 Tension (TS)

Tension is the strengthening of the body's mental and physical response to external things. Patients always have preoperative anxiety caused by nervousness (Oudkerk Pool et al., 2022). This is a human physiological emergency response that can be used to relieve patient tension through immersive listening and experience of the virtual natural environment (Kassahun et al., 2022). Especially for cardiac interventions, excessive preoperative anxiety often interferes with the performance of the procedure. Anxiety can cause a faster heart rate, increased blood flow, and higher blood pressure (Kapikiran et al., 2022; Reis et al., 2021). This can cause an increase in vascular pressure, leading to vascular distension, which increases the burden on the heart and is not conducive to the interventional procedure(Miyashita et al., 2022). Therefore, the relaxing environment and soothing music built by Metaverse can calm the patient's mind(Gold et al., 2021). Hence, the proposed hypothesis is:

Hypothesis 19 (H19): TS has a positive effect on patients' behavioural attitudes towards choosing metaverse surgery.
Hypothesis 20 (H20): TS contributes to the usefulness of metaverse surgery.

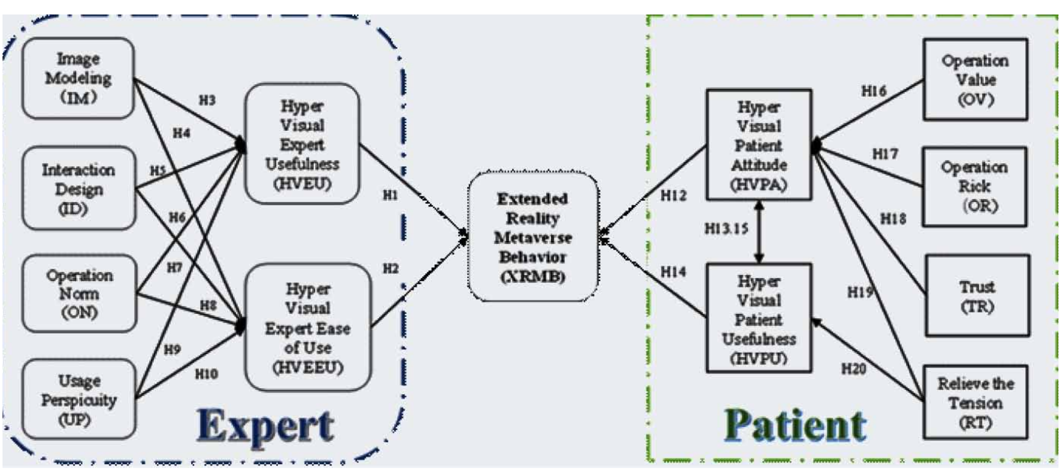
3.3 Structural Model

According to the above principles and hypotheses, the structural model is shown in Figure 2.

4. METHODOLOGY

The research methodology is an important decision making for the project of new things and new methods of certifying their new inner laws (Halis & Halis, 2022). According to the novelty of the technology of this research, it is currently in the nascent stage for the metaverse. Therefore, the triangular mixed research method is used, and the specific research methods are as follows: firstly, quantitative analysis is used to collect and analyze the relevant data (Zamir et al., 2022). Secondly, exploratory analysis (Yang et al., 2021) is used to ensure the comprehensiveness of this study by exploring unknown knowledge due to the lack of relevant information about extended reality and metaverse healthcare. Finally, a cross-sectional study was used to be able to examine specific issues (e.g., changes in patient mood with surgery time) without considering the effects of other variables, and some possible hidden relationships could be identified. The target population of this study was two, one being the surgical experts and the other being patients. Therefore, separate data collection was required, and the results were combined and analyzed. To simplify the collection method and reduce the cost, convenience sampling was used as the sampling method for this study. Data collection was performed by questionnaire with questions derived from available relevant information. The questions were ex-pressed in a simple, easy-to-answer manner. Respondents were informed that this data collection will ensure the security of personal information for all. The data collection method was

Figure 2.
Extended reality metaverse technology behavior model



mainly through the online collection (social networking software, email), combined with the on-site collection for the survey. For patients with different levels of literacy, professional doctors are required to cooperate with this data collection. Questions from patients were answered and explained. Both studies were collected over 3 months where the information filled by the respondents was one-off.

Data were processed using PLS-SEM equation modelling, a model that is now widely used in social science research (Simone et al., 2021). The model has multiple models and algorithms. It can provide a more comprehensive analysis of the intrinsic and extrinsic relationships of the variables. According to the specificity of this study, a systematic analysis of multiple, multivariate regressions was required. To ensure the integrity of the data and to avoid and reduce unnecessary errors caused by human factors.

5. DATA ANALYSIS

To ensure an adequate sample size for the study data, the minimum sample size for this study using SmartPLS was 174. The total number of data collected for surgeons and patients was 300 and 308 samples, respectively. Excluding invalid and missing data, the final valid questionnaires were 298 for surgeons and 300 for patients. Ac-cording to the social science questionnaire collection value, the relevant missing data need to be less than 5%(Memon et al., 2021), so the error of the two collection values is 0.77% and 2.67%, which meets the data research requirements. It is guaranteed that the existence of errors in this study will all have an impact on the results. The mean replacement of some missing data using Smart PLS was also used to maximize the efficiency of the data and ensure that the value of each variable was not affected.

5.1 Demographic Analysis

In Table 1, it is clear that surgical experts are highly educated and generally have a high level of education, with 37.58% of them having a postgraduate degree. Those aged 36-45 years accounted for 50% of the total number of respondents, which shows that these groups are the main users of metaverse surgery. Of the patients, there were 28 more male patients than female patients, and there were 214 people over 45 years old, which shows that the prevalence of middle-aged and elderly people is much high-er than that of young people. And this group is often resistant to surgery, due to a variety of reasons. It is mainly due to the poor credibility between doctors and patients and preoperative anxiety. These data are a true reflection of the current state of surgical procedures.

5.2 Statistical Analysis

In this study, the partial least squares variance method (PLS-SEM) was used for structural model analysis using SmartPLS 3.3.9 statistical software (Al Issa & Abdelsalam, 2021). The use of this software for data analysis facilitated the accuracy of the data results. The main reasons for using this software are 1. Because the related research is in its infancy, an exploratory research method was used and Smart PLS was able to conduct a theoretical base study on the variance, standard deviation, and internal and external structural relationships of the endogenous structure (Hair et al., 2021; Low et al., 2021). 2. The target population of this study is all Malaysian citizens with a large base population. The data cannot be fully averaged and requires the use of unconventional studies (Wang, Ma, Zhang et al, 2022).3. PLS-SEM is suitable for dealing with complex models, and this study uses a triangular mixed study approach with a TBM model and has two parts. It is very suitable for the multi-layer analysis using SmartPLS and the study of the relationship between internal and external correlates of each variable of the structure.

5.2.1 Common Method Bias

Since the data for this study were collected using only questionnaires, there was artificial covariance in that the data were obtained from the same subjects (Tan, 2022). Secondly, there was bias in the items of the questionnaire caused by the lack of clarity of individual questions, and confusion caused

Table 1.
Basic Information Analysis

Demographic characteristic	Options	Surgical Experts		Patients	
		Counts	Percentage (%)	Counts	Percentage (%)
Gender	Male	176	59.06%	164	54.67%
	Female	122	40.94%	136	45.33%
Age	20-35	103	34.56%	23	7.67%
	36-45	150	50.34%	63	21.00%
	46-55	37	12.42%	91	30.33%
	More than 56	8	2.68%	123	41.00%
Marital status	Single	102	34.23%	52	17.33%
	Married	196	65.77%	248	82.77%
Education	Junior and less	0	0.00%	11	3.67%
	high school	0	0.00%	47	15.67%
	Undergraduate	186	62.42%	153	51.00%
	Postgraduate	112	37.58%	89	29.67%
Income	Less than RM3000	4	1.37%	6	2.00%
	RM3000-5000	20	6.71%	89	29.67%
	RM5000-8000	120	40.27%	118	39.33%
	RM8000-10000	98	32.88%	52	17.33%
	More than RM10000	56	18.78%	35	11.67%

by contextual effects on the unique under-standing of the subjects (Radzi et al., 2022). A test for common method bias (CMB) is needed. It is the variance induced by factor analysis (Nguyen et al., 2021). It is caused by the subjective conscious choice of the subject (Sharma et al., 2022). So, first of all, it should be analyzed, in Table 2, the mean of the squared Ra2 of the substantive factor is 0.84948, the mean of the squared Rb2 of the method variance is 0.01262, and the ratio RATIO of the two is 67.3:1. According to Hari, et al. the ratio of the comprehensive variance of the substantive factor is greater than 39:1 (Hair & Alamer, 2022) and the CMB is not significant. Therefore, there is no effect of the CMB factor in the data of this study.

Table 2.
Common method Factor

Latent Construct	Indicators	Substantive Factor Loading (Ra)	Substantial Variance Square(Ra2)	Method Factor Loading (Rb)	Method Variance Square (Rb2)
ID	ID1	0.9283	0.86172	0.032	0.00102
	ID2	0.9178	0.84235	-0.075	0.00566
	ID3	0.9323	0.86923	0.050	0.00247
IM	IM1	0.9002	0.81042	0.025	0.00065
	IM2	0.9405	0.88461	-0.111	0.01242
	IM3	0.9099	0.82796	0.108	0.01160
ON	ON1	0.9348	0.87390	-0.003	0.00001
	ON2	0.9458	0.89456	0.060	0.00363
	ON3	0.9249	0.85548	-0.128	0.01646
UP	UP1	0.9276	0.86041	0.069	0.00472
	UP2	0.9249	0.85540	0.054	0.00295
	UP3	0.9033	0.81592	0.026	0.00066
OR	OR1	0.9290	0.86304	0.025	0.00063
	OR2	0.9170	0.84089	-0.111	0.01232
	OR3	0.9320	0.86862	0.107	0.01145
OV	OV1	0.9000	0.81000	-0.004	0.00002
	OV2	0.9400	0.88360	0.093	0.00865
	OV3	0.9110	0.82992	-0.148	0.02190
RT	RT1	0.9280	0.86118	0.054	0.00292
	RT2	0.9250	0.85563	0.06	0.00360
	RT3	0.9030	0.81541	0.026	0.00068
TR	TR1	0.9350	0.87423	-0.128	0.01638
	TR2	0.9460	0.89492	0.069	0.00476
	TR3	0.9240	0.85378	-0.06	0.00360
HVEU	HVEU1	0.9256	0.85679	-0.055	0.00299
	HVEU2	0.9294	0.86376	0.240	0.05743
	HVEU3	0.8952	0.80135	-0.189	0.03583
HVEEU	HVEEU1	0.8998	0.80968	-0.002	0.00000
	HVEEU2	0.9174	0.84167	-0.031	0.00093
	HVEEU3	0.9428	0.88894	0.032	0.00105
HVPA	HVPA1	0.9260	0.85748	0.033	0.00109
	HVPA2	0.9290	0.86304	-0.075	0.00563
	HVPA3	0.8950	0.80103	0.05	0.00250
HVPU	HVPU1	0.8990	0.80820	-0.002	0.00000
	HVPU2	0.9180	0.84272	-0.031	0.00096
	HVPU3	0.9430	0.88925	0.034	0.00116

continued on following page

Table 2.
Continued

Latent Construct	Indicators	Substantive Factor Loading (Ra)	Substantial Variance Square(Ra2)	Method Factor Loading (Rb)	Method Variance Square (Rb2)
XRMB	XRMB1	0.8898	0.79174	0.093	0.00864
	XRMB2	0.9377	0.87929	-0.148	0.02183
	XRMB3	0.9354	0.87503	-0.059	0.00346
	XRMB4	0.8900	0.79210	-0.055	0.00303
	XRMB5	0.9380	0.87984	0.241	0.05808
	XRMB6	0.9350	0.87423	-0.189	0.03572
	AVG		0.84948		0.01262
	RATIO	67.30			

Note: IM=Image Modeling; ID=Interaction Design; ON=Operation Norm; UP=Usage Perspicuity; HVEU= Hyper Visual Expert Usefulness; HVEEU= Hyper Visual Expert Ease of Use; XRMB=Extended Reality Metaverse Behavior; HVPA= Hyper Visual Patient Attitude; HVPU= Hyper Visual Patient Usefulness; OV=Operation Value; OR=Operation Rick; TR=Trust; RT=Relieve the Tension.

5.2.2 Outer Measurement Model

In using the PLS-SEM model, an assessment was used to detect the internal consistency reliability, Indicator reliability, and Average Variance Extracted (AVE) metrics of its reflectance measurement model(Ali et al., 2021). According to Harit's study, The thresholds for internally consistent composite reliability and indicator loading thresholds were higher than 0.70 (Zhao et al., 2022)for internal consistency and 0.80 for exploratory studies (Sun et al., 2022), consisting mainly of Composite Reliability and Cronbach's Alpha, and all values for both data sets in Table 3 were greater than 0.90, indicating extremely high reliability. Indicated reliability is a measure of how much indicator variation there is, by the indicator Loading its use for exploratory experimental studies threshold higher than 0.70 (Li, Wei, Li et al, 2020). The actual data are all higher than 0.9, with significant indicator reliability. The convergent validity of the model for the external loads by AVE calculation is due to be higher than 0.5, but the effective value is higher than 0.708 because the AVE of the potential construct is higher than the Fornell Larcker criterion. The current data indicate that the AVE is higher than 0.8, which meets the model requirements.

In assessing validity analysis, Hetero-Trait-Mono-Trait (HTMT) was mainly used for significant differences between variables (Kautsarina, 2020). It is the ratio of the mean values of the different constructs of the different variables to their mean values of the same constructs, with a threshold value of less than 0.85, and in Table 4 it can be seen that both the surgical specialist and patient models meet the criteria. HTMT inference was performed by Bootstrapping for subsamples 5000 operations to the data in Table 5. the confidence intervals of the obtained results were 95% and 5% values were between the thresholds [-1,1] (Dash & Paul, 2021). The bias correction and acceleration (BCa) values are wirelessly close to 0. The results obtained surface that the structural model composed of the factors of the variables inherently has a valid association.

5.2.3 Internal Measurement Model

The internal structural model is shown in Table 6 and the standard deviation is a measure of the deviation between the independent and dependent variables in the structural model with a maximum deviation value of 0.066 and a minimum value of 0.048. Based on Zeng, et al study the standard deviation value should be less than 0.168(Zeng et al., 2021), which proves that the deviation of this structural model has not affected it. Secondly, the minimum value of 5% and the maximum value of 95% of the confidence interval are between [-1,1](Basco et al., 2021), and there is a valid confidence

Table 3.
Convergent Validity and Construct Reliability

Latent Construct	Loadings	Standard Deviation	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
OR	0.9259	0.3600	0.9171	0.9259	0.9474	0.8572
OV	0.9169	0.3634	0.9053	0.9067	0.9407	0.8410
RT	0.9185	0.3630	0.9074	0.9100	0.9418	0.8436
TR	0.9352	0.3565	0.9283	0.9285	0.9544	0.8746
ID	0.9189	0.3608	0.9170	0.9210	0.9474	0.8573
IM	0.9167	0.3634	0.9051	0.9077	0.9406	0.8407
ON	0.9354	0.3564	0.9287	0.9298	0.9546	0.8751
UP	0.9179	0.3633	0.9067	0.9092	0.9414	0.8426
HVEU	0.9165	0.3636	0.9048	0.9069	0.9404	0.8402
HVEEU	0.9199	0.3619	0.9095	0.9167	0.9430	0.8466
HVPU	0.9166	0.3617	0.9094	0.9224	0.9428	0.8461
HVPA	0.9167	0.3636	0.9051	0.9067	0.9405	0.8406
XRMB	0.9213	0.3671	0.9072	0.9145	0.9417	0.8433

Note: IM=Image Modeling; ID=Interaction Design; ON=Operation Norm; UP=Usage Perspicuity; HVEU= Hyper Visual Expert Usefulness; HVEEU= Hyper Visual Expert Ease of Use; XRMB=Extended Reality Metaverse Behavior; HVPA=Hyper Visual Patient Attitude; HVPU= Hyper Visual Patient Usefulness; OV=Operation Value; OR=Operation Rick; TR=Trust; RT=Relieve the Tension.

interval between the variables. The P-value significance differences were 0.05, 0.01, and 0.001 from low to high(Li, Du, & Long, 2020). in Table 6 and Figure 3, it was assumed that HVEU (H1: B=0.547, P<0.001) XRMB became positively correlated. HVEEU (H2: B=0.262, P<0.001; H3: B=0.192, P<0.001) was assumed to have an enhancing effect on HVEU and XRMB. It is assumed that IM, ID, ON, UP, (H4: B=0.164, P<0.01; H5: B=0.154, P<0.01; H6: B=0.229, P<0.01: H7: B=0.235, P<0.001; H8: B=0.169, P<0.001; H9: B=0.291, P<0.001; H10: B=0.133, P<0.001; H11: B=0.139, P<0.01) For surgical experts there was a significant improvement in efficiency and ease of use. For the patient experience of virtual surgery ATB (H12: B=0.541, P<0.001; H13: B=0.487, P<0.001) was positively related to XRMB and HVPU. HVPU (H14: B=0.264, P<0.001; H15: B=0.195, P<0.001) had a positive effect on ATB and XRMB. Assuming OV, OR, TR, RT (H16: B=0.347, P<0.001; H17: B=0.174, P<0.01; H18: B=0.226, P<0.001; H19: B=0.154, P<0.01; H20: B=0.212, P<0.001) patients were able to understand the procedure for the use of virtual surgery, the process, alleviate preoperative anxiety, and improve patients' confidence.

5.2.4 Predictive Relevance and Effect Size

The predictive power of the model is also examined, which is to check the significance of the relevant data not used outside the model for the framework of the experimental study. The main metric is the detection of the Stone Geisserde Q-value. When the Q2 value > 0(Low et al., 2021), it indicates

Table 4.
Hetero-Trait-Mono-Trait (HTMT)

Surgical Experts							
	ID	**IM**	**ON**	**UP**	**XRMB**	**HVEU**	**HVEEU**
ID							
IM	0.682						
ON	0.664	0.544					
UP	0.633	0.625	0.444				
XRMB	0.645	0.654	0.604	0.685			
HVEU	0.747	0.654	0.640	0.605	0.774		
HVEEU	0.649	0.572	0.621	0.525	0.643	0.665	
Patient							
	HVPA	**OR**	**OV**	**RT**	**TR**	**XRMB**	**HVPU**
HVPA							
OR	0.743						
OV	0.649	0.678					
RT	0.597	0.624	0.625				
TR	0.638	0.665	0.541	0.436			
XRMB	0.772	0.642	0.654	0.684	0.601		
HVPU	0.662	0.650	0.570	0.519	0.622	0.642	

Note: IM=Image Modeling; ID=Interaction Design; ON=Operation Norm; UP=Usage Perspicuity; HVEU= Hyper Visual Expert Usefulness; HVEEU= Hyper Visual Expert Ease of Use; XRMB=Extended Reality Metaverse Behavior; HVPA= Hyper Visual Patient Attitude; HVPU= Hyper Visual Patient Usefulness; OV=Operation Value; OR=Operation Rick; TR=Trust; RT=Relieve the Tension.

that the path is significant for the model. The values of Q2 for each variable factor in Table 7 are greater than 0, indicating the predictiveness of each path in the PLS model for a certain endogenous structure(Mishra & Nikzad-Langerodi, 2021). In Table 8, a secondary authentication of Q2 was performed by two methods (cross-validation commonality method and PLS-SEM) to ensure the accuracy of the results and to predict the data that could be eliminated.

Q2 is the predictive assessment of the endogenous structure, in addition to the examination of the effect size, which is the assessment of the substantial impact of the endogenous structure, usually identified by f2(Lin et al., 2020). The criteria for judging the effect are 0.35, 0.15, and 0.02, respectively(Popa et al., 2022). When the actual data is less than 0.02, it has no effect. In Table 9, the values are all greater than 0.02, especially the HVEU effect on XRMB is 0.616. In the patient data, HVPA has a greater effect on the patient's use of the metaverse procedure. This shows that both surgical experts and patients have a positive impact significance and a high impact effect on using the new technology in clinical surgery.

5.2.5 Importance of Performance Map

Important performance map analysis (IPMA) is an effective method for examining variable paths in PLS-SEM models. It is a meaningful comparison of the analysis paths for the overall effect, by looking at the Index Value threshold. In Table 10 the overall effect is at a higher value than 0.35 than the minimum value of 0.02. The total impact data value was higher than 0.35, indicating that both groups of

Table 5.
Hetero-Trait-Mono-Trait (HTMT inference)

	Original Sample (O)	Sample Mean (M)	Bias	5.00%	95.00%
ID -> HVEU	0.300	0.299	-0.001	0.215	0.388
ID -> HVEEU	0.240	0.235	-0.005	0.136	0.349
IM -> HVEU	0.145	0.146	0.002	0.052	0.236
IM -> HVEEU	0.154	0.154	0.001	0.044	0.258
ON -> HVEU	0.166	0.169	0.002	0.079	0.261
ON -> HVEEU	0.290	0.291	0.002	0.203	0.385
UP -> HVEU	0.135	0.133	-0.002	0.056	0.214
UP -> HVEEU	0.138	0.139	0.000	0.052	0.235
HVEU -> XRMB	0.547	0.547	0.000	0.443	0.644
HVEEU -> XRMB	0.261	0.262	0.001	0.153	0.367
HVEEU -> HVEU	0.192	0.192	0.000	0.107	0.284
HVPA -> XRMB	0.542	0.541	-0.002	0.416	0.653
HVPA -> HVPU	0.488	0.487	-0.001	0.374	0.596
OR ->HVPA	0.350	0.347	-0.003	0.243	0.454
OV ->HVPA	0.172	0.174	0.002	0.060	0.284
RT -> HVPA	0.158	0.154	-0.004	0.059	0.259
RT -> HVPU	0.214	0.212	-0.002	0.104	0.329
TR -> HVPA	0.220	0.226	0.006	0.111	0.321
HVPU -> XRMB	0.265	0.264	-0.001	0.144	0.395

Note: IM=Image Modeling; ID=Interaction Design; ON=Operation Norm; UP=Usage Perspicuity; HVEU= Hyper Visual Expert Usefulness; HVEEU= Hyper Visual Expert Ease of Use; XRMB=Extended Reality Metaverse Behavior; HVPA= Hyper Visual Patient Attitude;HVPU= Hyper Visual Patient Usefulness; OV=Operation Value; OR=Operation Rick; TR=Trust; RT=Relieve the Tension.

surgical specialists and patients studied hypothesized a significant positive impact of the independent, and medium variables on the expanded reality metaverse surgery (Manley et al., 2020). For Index Value, all values are greater than 65(Sarstedt et al., 2022). The mean model performance significance values for ID, ON, and HVEU are 76.27, 70.76, and 71.63 for surgical Experts, respectively, which are at a high level, and the mean model performance significance values for HVPA and TR are 71.54 and 70.847 for patients, respectively, which also have high-level effects. This shows that each of the variable factors has a positive impact on the change in the user's usage behavior.

6. FINDING AND DISCUSSION

The data results show that the usefulness and ease of use of extended reality technology for medical experts in the use of metaverse for surgery have significantly improved the effect of surgery in the actual operation of surgery. In the study of Cofano et al., a head-mounted display was used for spinal surgery, and the construction of 3D images could effectively segment the patient's blood vessels and aneurysms (Cofano et al., 2021). It can be scaled and placed anywhere within the surgeon's field of view (Xi et al., 2022), reducing unnecessary field requirements. Make sure the surgeon's field of view is focused on the operating table (Jung et al., 2021). In cardiothoracic medicine, research by Sadeghi et al. shows that XR technology provides surgery with a realistic view of the tissue structure and

Table 6.
Hypothetical structure model

Hyp	PLS Paths	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	5.00%	95.00%	P Values	Remarks
H1	HVEU -> XRMB	0.547	0.547	0.061	8.916	0.444	0.645	0.0000	Yes
H2	HVEEU -> XRMB	0.261	0.262	0.065	4.025	0.156	0.369	0.0000	Yes
H3	HVEEU -> HVEU	0.192	0.192	0.054	3.558	0.104	0.280	0.0002	Yes
H4	IM -> HVEU	0.145	0.146	0.056	2.563	0.056	0.239	0.0052	Yes
H5	IM -> HVEEU	0.154	0.154	0.064	2.398	0.046	0.259	0.0083	Yes
H6	ID -> HVEU	0.300	0.299	0.053	5.687	0.212	0.386	0.0000	Yes
H7	ID -> HVEEU	0.240	0.235	0.066	3.658	0.125	0.340	0.0001	Yes
H8	ON -> HVEU	0.166	0.169	0.056	2.986	0.080	0.263	0.0014	Yes
H9	ON -> HVEEU	0.290	0.291	0.055	5.259	0.203	0.385	0.0000	Yes
H10	UP -> HVEU	0.135	0.133	0.048	2.790	0.054	0.212	0.0026	Yes
H11	UP -> HVEEU	0.138	0.139	0.055	2.509	0.049	0.231	0.0061	Yes
H12	HVPA -> XRMB	0.542	0.541	0.060	9.112	0.416	0.653	0.0000	Yes
H13	HVPA-> HVPU	0.488	0.487	0.058	8.445	0.373	0.593	0.0000	Yes
H14	HVPU -> XRMB	0.265	0.264	0.063	4.200	0.141	0.392	0.0000	Yes
H15	HVPU -> HVPA	0.192	0.195	0.054	3.544	0.086	0.303	0.0000	Yes
H16	OR -> HVPA	0.350	0.347	0.054	6.480	0.240	0.452	0.0000	Yes
H17	OV -> HVPA	0.172	0.174	0.059	2.892	0.067	0.284	0.0043	Yes
H18	TR -> HVPA	0.220	0.226	0.054	4.119	0.125	0.331	0.0000	Yes
H19	RT -> HVPA	0.158	0.154	0.051	3.104	0.050	0.255	0.0021	Yes
H20	RT -> HVPU	0.214	0.212	0.060	3.529	0.104	0.329	0.0001	Yes

Note: a. IM=Image Modeling; ID=Interaction Design; ON=Operation Norm; UP=Usage Perspicuity; HVEU= Hyper Visual Expert Usefulness; HVEEU= Hyper Visual Expert Ease of Use; XRMB=Extended Reality Metaverse Behavior;HVPA= Hyper Visual Patient Attitude;HVPU= Hyper Visual Patient Usefulness; OV=Operation Value; OR=Operation Rick; TR=Trust; RT=Relieve the Tension. b. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$, ^{NS} insignificant

Figure 3.
Sample Mean Theoretical Framework

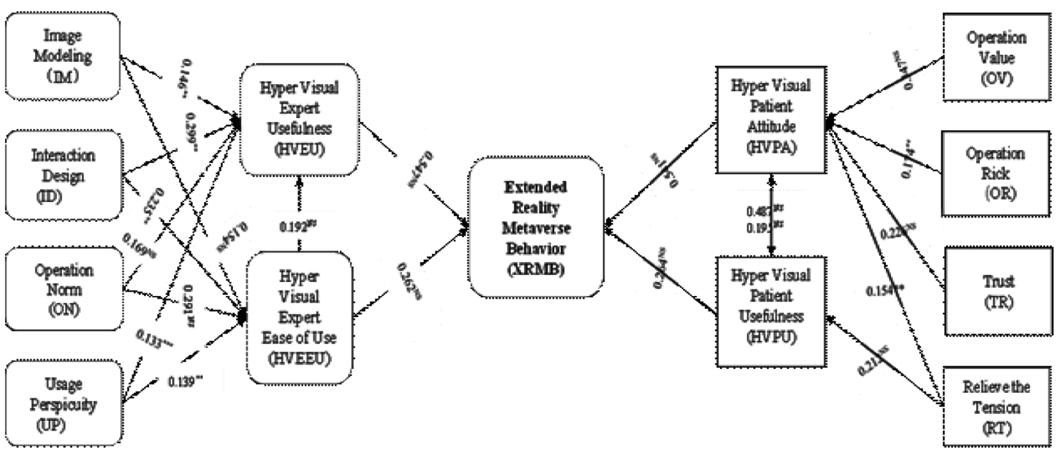


Table 7.
Predictive Relevance

Surgical Experts				
	SSO	SSE	Q^2 (=1-SSE/SSO)	Predictive Relevance
ID	894	296.1575	0.6687	$Q^2>0$
IM	894	321.5542	0.6403	$Q^2>0$
ON	894	268.2365	0.7000	$Q^2>0$
UP	894	319.1091	0.6431	$Q^2>0$
XRMB	6258	3118.6984	0.5016	$Q^2>0$
HVEU	4470	2255.1704	0.4955	$Q^2>0$
HVEEU	5364	2742.3058	0.4888	$Q^2>0$
Patient				
	SSO	SSE	Q^2 (=1-SSE/SSO)	Predictive Relevance
HVPA	4500	2240.034	0.5020	$Q^2>0$
OR	900	297.897	0.6690	$Q^2>0$
OV	900	323.655	0.6400	$Q^2>0$
RT	900	319.205	0.6450	$Q^2>0$
TR	900	271.196	0.6990	$Q^2>0$
XRMB	6300	3152.133	0.5000	$Q^2>0$
HVPU	5400	2728.962	0.4950	$Q^2>0$

Note: a. IM=Image Modeling; ID=Interaction Design; ON=Operation Norm; UP=Usage Perspicuity; HVEU= Hyper Visual Expert Usefulness; HVEEU= Hyper Visual Expert Ease of Use; XRMB=Extended Reality Metaverse Behavior;HVPA= Hyper Visual Patient Attitude;HVPU= Hyper Visual Patient Usefulness; OV=Operation Value; OR=Operation Rick; TR=Trust; RT=Relieve the Tension.

Table 8.
PLS Predict Results

	PLS-SEM			Linear model benchmark		
	Q2_predict	RMSE	MAE	Q2_predict	RMSE	MAE
XRMB	0.411	0.803	0.67	0.516	0.728	0.595
HVEU	0.454	0.857	0.663	0.493	0.827	0.639
HVEEU	0.372	0.907	0.741	0.42	0.871	0.715
ATB	0.453	0.858	0.663	0.489	0.829	0.64
HVPU	0.331	0.934	0.790	0.418	0.871	0.713

Note: HVEU= Hyper Visual Expert Usefulness; HVEEU= Hyper Visual Expert Ease of Use; XRMB=Extended Reality Metaverse Behavior; HVPA= Hyper Visual Patient Attitude; HVPU= Hyper Visual Patient Usefulness

Table 9.
Effect Size (f^2)

Surgical Experts							
	ID	**IM**	**ON**	**UP**	**XRMB**	**HVEU**	**HVEEU**
ID					0.297	0.386	0.250
IM					0.142	0.171	0.153
ON					0.208	0.220	0.306
UP					0.131	0.159	0.139
HVEU					0.616		
HVEEU					0.360	0.199	
Patient							
	HVPA	**OR**	**OV**	**RT**	**TR**	**XRMB**	**HVPU**
HVPA						0.743	0.542
OR	0.386					0.287	0.209
OV	0.170					0.126	0.092
RT	0.156					0.164	0.283
TR	0.220					0.164	0.119
HVPU						0.241	

Note: IM=Image Modeling; ID=Interaction Design; ON=Operation Norm; UP=Usage Perspicuity; HVEU= Hyper Visual Expert Usefulness; HVEEU= Hyper Visual Expert Ease of Use; XRMB=Extended Reality Metaverse Behavior; HVPA= Hyper Visual Patient Attitude; HVPU= Hyper Visual Patient Usefulness; OV=Operation Value; OR=Operation Rick; TR=Trust; RT=Relieve the Tension.

environment, provides interactive digital projections, and satisfies the use of surgical goals (Sadeghi et al., 2022). In Zhang et al.'s study of neurosurgery, surgeons used metaverse technology to precisely locate blood vessels and nerves, saving time for tissue dissection during surgery (Yinglong et al., 2022). Hence H1 and H2 are established.

The new technology simplifies the need to use a mouse or keyboard in the original operation, and for the monitoring of multiple monitors (Panusa et al., 2022), the XR system can connect multiple devices at the same time through the computer, process the data, and alert the doctor in a time when an abnormality is found, reducing the time to view the equipment (Taylor et al., 2022). This suggests that the ease of use of the technology is a measure of usefulness. Hence H3 is established. Image modelling mainly uses CT, and PET/CT scan images to perform 3D (Chen et al., 2022; Palaniappan et al., 2022) and converts the images from 2D to 3D, which is helpful for doctors to view the lesions (Lu et al., 2022). The findings of Triberti et al., al-low surgeons to use a realistic-looking image that can overlap the patient's body, facilitating the localization of blood vessels and nerves (Triberti et al., 2021).

Supports the establishment of H4 and H5. The use of a variety of interactive methods facilitates the operation. For example, in the realization of remote surgery, surgical experts can communicate and communicate remotely through the voice system (Kitagawa et al., 2022). The use of eye tracking facilitates the free switching of multi-image viewing during expert surgery, identifying commands by sclera and blink rate (Dimigen & Ehinger, 2021). The improvement of tactile sense is conducive to the control of the strength of open-chest cardiac compression and avoids cardiac compression injury caused by excessive strength (Klaib et al., 2021). Hence H6 and H7 are established. In surgical anaesthesia, the use of XR technology enables the automated use of fixed detectors to detect the likelihood of occurrence during patient anaesthesia care (Le Noury et al., 2022). And there is no risk to the patient. For the transmitted data, the system can make correct judgments and give timely

Table 10.
Importance Performance Map Results

Surgical Experts		
Importance (Total Effect)	Importance (Total Effect)	Performances (Index Value)
ID	0.3600	76.2729
IM	0.3634	65.3045
ON	0.3564	70.7551
UP	0.3633	65.3480
XRMB	0.3616	67.9770
HVEU	0.3636	71.6312
HVEEU	0.3619	68.4708
Patient		
Importance (Total Effect)	Importance (Total Effect)	Performances (Index Value)
HVPA	0.3637	71.538
OR	0.3597	76.396
OV	0.3633	65.287
RT	0.363	65.265
TR	0.3563	70.847
XRMB	0.3617	67.944
HVPU	0.3617	68.574

Note IM=Image Modeling; ID=Interaction Design; ON=Operation Norm; UP=Usage Perspicuity; HVEU= Hyper Visual Expert Usefulness A; HVEEU= Hyper Visual Expert Ease of Use; XRMB=Extended Reality Metaverse Behavior; HVPA= Hyper Visual Patient Attitude; HVPU= Hyper Visual Patient Usefulness B; OV=Operation Value; OR=Operation Rick; TR=Trust; RT=Relieve the Tension.

warnings for abnormal values (Lueck & Bachen, 2021). It can also provide an operation video with instructions for use, which is helpful for doctors and nurses to quickly grasp the correct operation of the new equipment (Morimoto et al., 2022). For wrong use, give warnings and hints. Therefore, H8 and H9 are established. Head-mounted displays with high-definition cameras can improve visibility to the human eye, especially for wide-angle images (Saito et al., 2022; Tokunaga et al., 2022). By using Microsoft HoloLens 2, surgical experts can effectively improve the clarity of the fluoroscopy field, which is conducive to quickly calibrating the reference position and inserting the guide wire (Su et al., 2022). By using smart glasses, the time for wire insertion is reduced and the cost of surgery is saved. Therefore, H10 and H11 are established.

From the patient's perspective, it can be concluded that both behavioural attitudes and extended reality technology have a positive impact on the change in patient behaviour. Behavioural attitude is the change of subjective consciousness, and it is the process of a user's consciousness-perceived usefulness-behaviour change (Bosnjak et al., 2020). Studies have shown that the improvement of surgical value, the reduction of surgical risks, the deepening of doctor-patient trust, and the relief of preoperative anxiety all have a change in behavioural choices for patients when choosing surgery, and the use of new technologies has a positive effect on patients' preoperative psychological changes. Therefore, H12 and H13 are established. In the Simone study, by simulating virtual surgery, patients can visualize the surgical process through the doctor's elaboration (Simone et al., 2021). When patients directly experience intelligent surgery, it can effectively reduce the fear of surgery. Because virtual surgery can have a more realistic understanding of surgical risks (Southworth, Silva, Blume et al, 2020). At the same time, it increases the trust of patients in doctors. For the study of human monitoring values, the use of XR is beneficial for patients to maintain normal blood pressure and heart rate before surgery (Osorto Carrasco & Chen, 2021; Rojo et al., 2021). Therefore, H14 and H15 are established. In the embodiment of operational value, patients are mainly passively perceived by doctors (Koo, 2021).

The users of metaverse surgery are surgical experts. Through their experience, patients are informed that the use of new technologies is better than traditional surgery. Existing research shows that XR technology has significantly improved image display, visual field clarity, and interactive applications (Goo et al., 2020; Kim et al., 2021). So H16 is established. There are two ways to reduce the risk of surgery. One is that as mentioned above, the XR system has a supervisory role in the operation of surgical experts, which can improve the standardization of surgical experts. Second, preoperative drills can be carried out through virtual surgery, especially for some special and complex stripping operations, multiple preoperative simulation exercises are conducive to formulating a complete surgical plan and reducing the occurrence of surgical risks (Levy et al., 2021; Triberti et al., 2021). So H17 is established. The trust of doctors and patients is often one of the main problems in the success of surgery (Tan, 2022). The use of XR in tumour surgery can help reduce the occurrence of adverse events, improve the diagnostic level of experts, and help patients participate in treatment with a positive attitude (Alrishan Alzouebi et al., 2021; Gold et al., 2021). This increases the patient's trust in surgical expertise. So H18 is established. In studies of preoperative anxiety, VR has been shown to reduce pain and anxiety in patients of various levels, including heart surgery (Stromberga et al., 2021), organ transplant surgery(Danziger-Isakov et al., 2021), urological surgery(Amparore et al., 2022), and wound dressing changes. Immersive listening to music (Kakar et al., 2021), in a virtual natural environment (Wang, Li, An et al, 2022), can effectively relieve the patient's preoperative tension. In a study by Kapikiran, et al., head-mounted displays were effective in reducing anxiety in pre-transplant patients and watching videos using the head-mounted display was more relaxing (Kapikiran et al., 2022). There-fore, H19 and H20 are established.

The study shows that the use of the Extended Reality Metaverse in surgery changes traditional planar imaging, where images can be modified in colour to help differentiate between different tissues. The combined use of multiple interactions facilitates the communication between nurses during the operation, the sharing of images, and the improvement of tactile sensitivity. The identification and monitoring technology of the XR system can supervise the operation of the surgical process, find problems in time, and make prompts. These advantages are beneficial to improve the efficiency of surgery and reduce the operation time. The use of virtual surgery is conducive to the simulation training of difficult operations, the teaching and learning of students, and the introduction of patients' conditions. Through stereoscopic imaging, it is easier for patients to understand the actual surgical process and to assess risks. It is no longer a unilateral chief complaint of the doctor. Due to the different educational levels of the patient, the patient cannot fully understand what the doctor said. Therefore, the patient can correctly understand the condition, so that the behaviour of the metaverse surgery can be changed. Therefore, this study is a more comprehensive study from the perspectives of surgical experts and patients, which shows the recognition of surgical experts and patients for intelligent surgery. Each variable has an obvious internal in-fluence on the dependent variable, and the research results are valid.

7. CONTRIBUTION

Address the limitations of existing clinical surgical techniques and improve surgery using metaverse technology. By surveying both surgical specialists and patients, for the operator and beneficiary of the surgery, respectively, we can provide a comprehensive response to the degree of acceptance and recognition of the new technology for surgery by both doctors and patients. This study has the following contributions.

7.1 Theoretical Contributions

The Technology Behavior Model is the theoretical framework used in this study. The model is based on a combination of the technology acceptance model and the theory of planned behaviour. With the user's recognition of the usefulness of the technology and the change in the perceived behaviour concerning the technology perception. It can reflect the change in the user's subjective thinking and the transformation of the technology for their behavioural use, both in terms of internal human psychological changes and external changes of new things or new technologies. It is a more comprehensive response to the active shift of the old behaviour to the new behaviour. Therefore, the technology behaviour model can effectively enhance the one-sidedness of TAM or TPB alone, which lacks a comprehensive examination of human behaviour changes, and is more in line with the user's recognition of the use of new technology.

7.2 Methodological Contributions

The current methodological contribution is the adoption of a triangulation study methodology.1 A quantitative study was used. For the overall control of quantity, the study population is more indeterminable, so the total population of Malaysia was used as the base for this study. This was able to avoid errors caused by the small sampling size of the sample. This resulted in the inability to conduct experimental studies.2, There is too little existing literature on the study of new technologies in the medical field, especially since there is no research specifically on the holistic nature of clinical surgery. There is a need to propose practical problems applicable to users for me-ta-universe, extended reality, mixed reality, and virtual surgery based on the existing technologies related to the use of meta-universe, extended reality, mixed reality, and virtual surgery in various surgeries and other uses in the medical field. The proposed questions should be acceptable to different populations. This will objectively reflect the actual thoughts of the respondents.3. A cross-sectional study is mainly beneficial to the researcher for data collection that cannot be sampled in a comprehensive average. It is good for the analysis of the collected data in the available time, to avoid some errors caused by human beings. So this mixed research method avoids the limitations of using one of the methods alone and gives a reasonable explanation for the data collection and the study of the problem. The error of human and single questionnaire collection is reduced.

7.3 Social Contribution

Metaverse surgery offers a new type of surgery, compared to traditional surgery that relies only on the skills of surgical specialists, using 2D images to identify and assess the ease and risk of surgery. First, it gives young surgeons more possibilities to participate in the surgery. This ensures that there will be enough doctors in some areas. Secondly, it allows surgical specialists to be well prepared for the challenges of difficult surgery by providing high-definition, cuttable stereoscopic holographic medical images, including the ability to perform multiple virtual surgical studies and studies before surgery. The chances of patient survival are improved. Once again, the ability to per-form remote clinical surgery solves the challenge of access to care and reduces the cost of surgery. These are the effects of the development of extended reality technologies that have a direct impact on prolotherapy. From an economic point of view, the use of new technologies, the reduction of the difficulty of surgery, the reduction of surgery time (the impact of radiation on the body of the doctor and patient during surgery), and the direct effect of labour costs on the reduction of surgery costs. Fundamentally, it solves the problem of medical level differences caused by geographic location and economic differences that lead many patients to give up treatment and life. It is important for the development of human health and true love of life.

8. CONCLUSION

This study is an exploration of the use of the metaverse in surgery. The triangular mixed research method is adopted, which avoids the limitations of single-method re-search and many errors. The use of the three methods is conducive to the exploration of the use of the metaverse in unknown fields and avoids cognitive differentiation based on human subjective consciousness. The study is the first to examine the individual perspectives of surgical Experts and patients. Data were collected through different questionnaires. A comprehensive review of the acceptance of the new technology in surgery by both sides of the surgery was conducted. This data analysis adopts PLS-SEM. For mixed research based on exploratory research, PLS can systematically calculate the relationship between the internal and external factors of each variable factor of the model (Yu et al., 2021). Using the compound method, the research on reliability, re-liability, validity and parallel algorithms makes the results obtained with high reliability. As a result, it appears that Extended Reality Metaverse Surgery is a significant improvement in the efficiency of the surgery in terms of usefulness. It is highly recognized by surgical Experts and patients for its use in surgery.

The main contribution of this study is to propose the use of extended reality technology for clinical surgery and to make the first two-way parallel study of surgeons and patients. Provides a basis for the use of the metaverse in surgery. In the future, the development of Metaverse surgery will solve the problems of regional differences at the medical level and the gradual increase in the demand for surgery due to an ageing population. Finally, online medical care and remote surgery can be performed at home.

Author Contributions: For research articles with several authors, a short paragraph specifying their contributions must be provided. The following statements should be used “Conceptualization, X.G, P.S.J; P.S.J., X.G.; software, X.G.; validation, X.G, P.S.J, .; formal analysis, X.G, and P.S.J; investigation, X.G.; resources, X.G.; data curation, X.G, P.S.J, writing—original draft preparation, X.G.; P.S.J., N.S., T.H.S., H.L., K.Y.P.; visualization, X.G; P.S.J; project administration, X.G.; funding acquisition, P.S.J, All authors have read and agreed to the published version of the manuscript.

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