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# A pilot study to evaluate the usability of an immersive virtual reality application for medical training in acute appendicitis.

# Estudio piloto para evaluar la usabilidad de una aplicación de realidad virtual inmersiva para la formación médica en apendicitis aguda.

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**Abstract.**
**Introduction:** Virtual reality (VR) is transforming medical education through didactic and interactive simulations of clinical cases. Immersive virtual reality (IVR) allows users to experience full immersion, creating the perception of being inside the simulated environment. **Objective:** To evaluate the usability of an IVR application designed for medical students' training in an acute appendicitis case. **Methods:** A pilot study was conducted with 20 sixth-year medical students. A questionnaire has been developed to assess usability, acceptability, and user satisfaction with the technology. Each variable was analyzed independently. **Results:** All participants completed the simulation without technical issues. Only one participant (5%) reported feeling dizziness during the simulation. Participants manifested high levels of adaptation to handling the technology (95%) and understanding of the simulation panels and instructions (100%). There was strong acceptance of this technology for acquiring new knowledge (90%) and for the estimated time required to consolidate clinical knowledge using this intervention (75%). **Conclusions:** Although IVR is still in its early stages of development, it is establishing new educational opportunities in medical training.

**Keywords:** Virtual Reality, Medical education, Pilot Study, Immersive Virtual Reality, Hospitals.

**Resumen.**
**Introducción:** La realidad virtual (RV) está transformando la educación médica mediante simulaciones didácticas e interactivas de casos clínicos. La realidad virtual inmersiva (RVI) permite que el usuario experimente una inmersión total haciéndole creer que se encuentra dentro de ese entorno ficticio. **Objetivo:** analizar la usabilidad de una aplicación de RVI destinada a la formación de estudiantes de medicina en un caso de apendicitis aguda. **Metodología.** Estudio piloto con 20 estudiantes de sexto año medicina. Se ha diseñado un cuestionario para evaluar la usabilidad, aceptabilidad y satisfacción del personal usuario con la tecnología. Se analizaron cada una de las variables de forma independiente. **Resultados:** Todo el personal participante completó la simulación sin problemas técnicos. Una única persona (5%) manifestó sentir mareos durante la simulación. Los/as participantes reportaron altos niveles de adaptación al manejo de la tecnología

(95%) y comprensión de los paneles e instrucciones de la simulación (100%). Se mostró una gran aceptación respecto al uso de esta tecnología para la adquisición de nuevo conocimientos (90%) y el tiempo estimado para asentar conocimientos clínicos con esta intervención (75%). **Conclusión:** A pesar de que la RVI se encuentre en sus fases iniciales de desarrollo, está generando nuevas oportunidades educativas en la formación médica.

**Palabras clave:** Realidad virtual, Educación médica, Estudio piloto, Realidad virtual inmersiva, Hospitales.

## 1. Introduction

In 2020, Sakai et al. (1), explained that Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR) were no longer futuristic inventions, but had become working tools that are undoubtedly changing and improving healthcare. These technologies have been introduced in the hospital environment with the clear goal of transforming traditional techniques through simulated environments that allow the interaction between virtual elements and the real environment.

Clinical training goes from isolated procedures or techniques to full clinical scenarios (2). In this context, VR offers the capacity to simulate all kinds of clinical scenarios, including those that are difficult to replicate. Its high scalability and adaptability are converting VR into a valuable educational tool for undergraduate medical students (3–5) . Furthermore, compared with traditional teaching methods, such as standardized patients, simulation manikins, or medical supplies, VR can provide a low-cost, time-efficient supplement for full-scale simulations (6-7).

While conventional VR displays virtual items on a computer screen, immersive virtual reality (IVR) is defined as a virtual interactive simulation projected onto head-mounted display, allowing for $360^0$ of visual immersion (8) and inducing the stressful experience of being present in an emergency department or clinical setting (9). Although numerous systematic reviews have examined the efficacy of traditional VR systems (10), evaluating the effectiveness of IVR in medical education remains a complex task and the number of studies on this topic remains limited (11).

This study aims to address this gap by advancing knowledge of IVR technology in medical education through the development and evaluation of an IVR-based educational application for undergraduate medical students. The virtual game replicates the entire clinical pathway, from the patient's arrival at the hospital until, due to its physical condition, it must undergo surgery. The IVR application has been assessed, focusing on usability, acceptability and users' satisfaction with this technology.

## 2. Methods

### *2.1. Study design and participants*

This study included the participation of 20 sixth-year medical students from the University of the Basque Country/Euskal Herriko Unibertsitatea (UPV/EHU). Data collection methods included a questionnaire and an analysis of participants' performance during the training scenarios. The questionnaire consisted of 13 items rated on a 5-point scale, where higher scores indicated greater usability, acceptability, and satisfaction with the virtual environment. Each item has been assessed and analyzed individually.

### *2.2. Technological specifications*

All the technological development was done using an HP Omen laptop 016 (x64 architecture), equipped with a Windows 11 operating system, an Intel Core Ultra 7-255H processor with 16 cores and 16 GB of RAM. The graphic processor is an NVIDIA® GeForce RTX™ 5060 Laptop GPU. The

VR application was designed using Unity® 3D software (11), a powerful free platform for creating games, apps and immersive experiences in real-time. The game design utilized Virtualware Immersive Room (VIROO) (12) for Unity 3D, a platform that enhances the creation and management of VR environments. This platform further streamlines the process, making it more accessible and robust. The immersive experience was delivered using Meta Quest 3S VR head-mounted displays (13).

*2.3. Virtual game*

The game is divided into two different scenarios. In the first scene, 14 years-old girl accompanied by her father arrives at the hospital emergency room due to intense pain in her stomach. Users must identify the patientś symptoms and her situation to decide which medical tests should be performed to obtain the correct diagnosis. All these decisions are made through multiple-choice question panels that guide users during the decision-making process. Since the final diagnosis of the patient is acute appendicitis, this one will require surgery.

The second scene takes place in the operating room. In this scene, users must fulfill all preoperative procedures in a structured sequence, replicating the standard surgical preparation protocol. This scene is also structured around multiple-choice question panels, although interactive surgical instruments have been configured allowing users to select the ones that are required for this surgery and after that, collocating them over the patient body. As this is a critical step in the process, specific visual guides are designed to instruct users on the proper sequence, position and orientation of these instruments. After each question panel or action, supplementary information is added by means of videos and explanatory audios justifying why it is the correct response (see Figure 1).

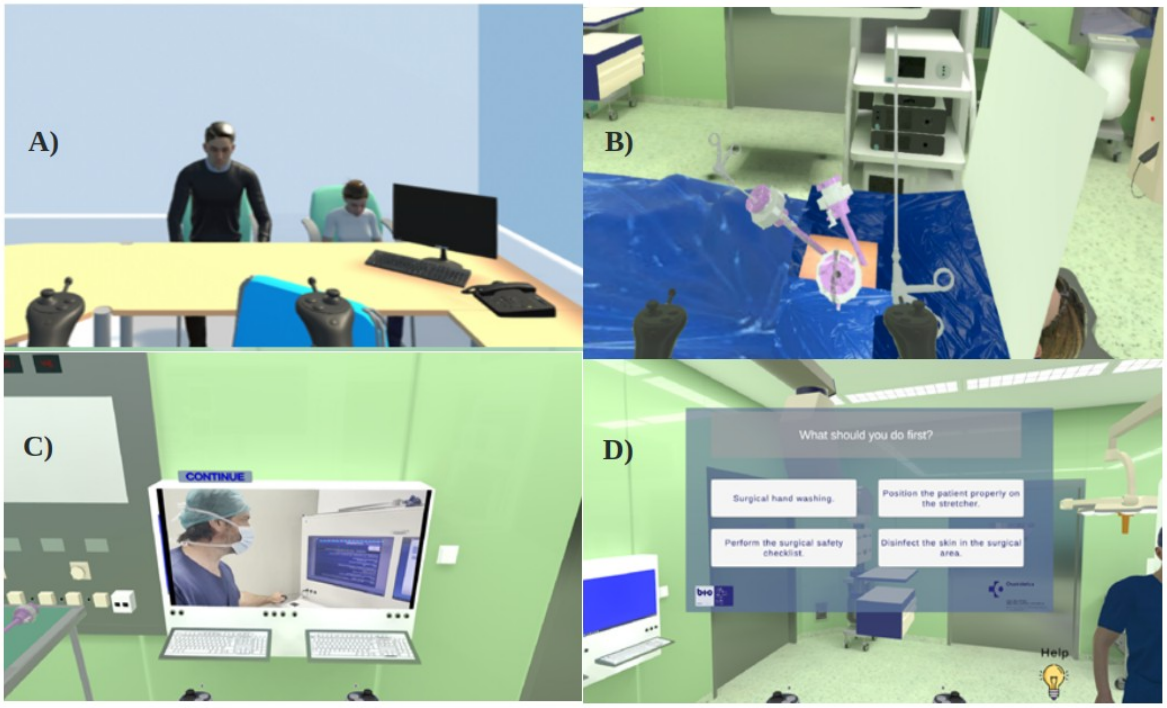


**Figure 1.** A) First scene. The patient is in the emergency room accompanied by her father. B) Second scene. Transparent guides for instruments collocation. C) Second scene. Video of a real surgery as supplementary information. D) Second scene. Interactive panel with multiple-choice question.

When the users fulfill all the surgical preparation procedures, a final panel appears showing the obtained final score. As a result, users can review both their correct and incorrect responses, allowing them to assess their level of understanding of the preparation process for acute

appendicitis surgery. To give a bigger realism to the virtual experience one of the operating rooms of the hospital has been scanned with a $360^0$ camera. All the surgical equipment, devices and instruments present in the operating room –including the laparoscopy tower, operating table, surgical lights, monitors, anesthesia carts,…-have also been individually scanned. This enables users to interact with them just as they would during surgery (see Figure 2).

### *2.4. Ethical Considerations*

This study received ethical approval from the Bilbao-Basurto Integrated Health Organization (IHO) research ethics committee. Participants provided informed consent before participating in the study, and their data has been kept confidential and anonymous.

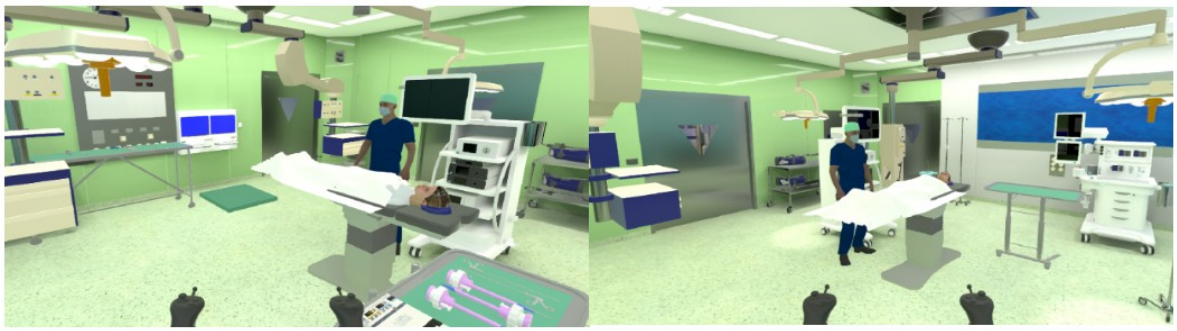

**Figure 2**. Second scene. Operating room.

## 3. Results

During the virtual session conducted with 20 students, all participants successfully completed the simulation without technical issues. An assistant supervised all IVR simulations but did not need to intervene at any point due to potential technical problems. One student reported experiencing dizziness during the virtual session; however, this did not prevent her from completing the activity (Q2) (table 1).

To ensure this virtual application's usability, its interfaces must be intuitive and easily understandable for users, without requiring extensive prior training (14)**.** At the beginning of the session, all participants received basic instructions on how to use the joysticks and the HMD. After completing the virtual experience, all participants except one (95%) reported that the technology was easy to use (Q1) and all of them stated that the instructions received during the simulation were straightforward and made possible to fulfill the full clinical procedure effortlessly (Q3 & Q6) (table 1).

Regarding the acceptability of this development as educational tool, 18 (90%) students strongly agreed that the didactic and interactive training offered through VR gamification facilitates the acquisition of new clinical knowledge (Q7). Similarly, 15 (75%) students believed that this technology would reduce the time needed to consolidate new concepts compared with traditional learning methods (Q10). Finally, all participants (100%) indicated that they would recommend the use of this technology for acquiring new knowledge (Q11) (table1).

**Table 1.** Usability, acceptability, and user satisfaction's questionnaires results

| Item | Description | Totally disagree n(%) | Disagree n(%) | Neutral n(%) | Agree n(%) | Totally agree n(%) |
|---|---|---|---|---|---|---|
| Q1 | Easy to use | 0 (%) | 0 (0%) | 1 (5%) | 1 (5%) | 18 (90%) |
| Q2 | No discomfort | 0 (%) | 1 (5%) | 1 (5%) | 2 (10%) | 16 (80%) |
| Q3 | Clear instructions | 0 (0%) | 0 (0%) | 0 (0%) | 2 (10%) | 18 (90%) |
| Q4 | Level of realism | 0 (0%) | 0 (0%) | 0 (0%) | 7 (35%) | 13 (65%) |
| Q5 | Real-time interactions | 0 (0%) | 0 (0%) | 0 (0%) | 5 (25%) | 15 (75%) |
| Q6 | Understandable panels | 0 (0%) | 0 (0%) | 0 (0%) | 3 (15%) | 17 (85%) |
| Q7 | Knowledge acquisition | 0 (0%) | 0 (0%) | 0 (0%) | 2 (10%) | 18 (90%) |
| Q8 | Prior basic instructions | 0 (0%) | 0 (0%) | 0 (0%) | 2 (10%) | 18 (90%) |
| Q9 | Understand the full case | 0 (0%) | 0 (0%) | 0 (0%) | 6 (30%) | 14 (70%) |
| Q10 | Reduce training time | 0 (0%) | 0 (0%) | 0 (0%) | 5 (25%) | 15 (75%) |
| Q11 | Recommend IVR | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 20 (100%) |
| Q12 | Practical application of knowledge | 0 (0%) | 0 (0%) | 1 (5%) | 8 (40%) | 11 (55%) |
| Q13 | Session global assessment | 0 (0%) | 0 (0%) | 0 (0%) | 1 (5%) | 19 (95%) |

## 4. Discussion

The literature reveals promising results in enhancing trainees' awareness and confidence in applying these skills in clinical practice through prior VR-based training (15). The interactive education offered in these virtual simulations, where users not only acquire theoretical knowledge but also learn about how to apply it into practice, allows users to gain professional experience safely, without compromising patients' quality of life (16). Likewise, this technology enables the development of multi-user platforms in which several participants can interact simultaneously within the same virtual environment, as they would during real surgical procedures. Such settings promote interpersonal communication, collaborative learning, and teamwork (17-18).

IVR is predominantly utilized for clinical surgery education (19), particularly in teaching complex scenarios (20) and situations that are difficult to replicate (21). However, its use as an assessment instrument is still emerging and, therefore, it is essential to conduct validity studies that examine both the absence of technical issues during simulations and the users' well-being (22), ensuring that no discomfort is experienced. Similarly, understanding user feedback is essential to continue improving its educational impact.

The results obtained in this study reveal a strong interest among students in incorporating this educational tool into their professional training. Many participants expressed that having access to this type of technology before entering an operating room for the first time would be highly beneficial, as the initial experience in the surgical setting is overwhelming and it is often difficult to retain all the information provided on that day. In the same way, some participants recommended adding a feature in the application to enable users to repeat explanations and actions or review question panels, providing an opportunity to consolidate understanding and re-experience essential procedures.

Given these results, the next step should be to assess the educational relevance of the application. As has been done in other studies (23-24) this assessment will involve a controlled trial comparing the clinical knowledge of two groups: an intervention group, consisting of professionals who have used the application, and a control group, comprising those who have not participated in this training.

VR applications are highly scalable (25-26). Although this article describes the virtual application developed for simulating an acute appendicitis clinical case, the intention is to expand and adapt the environment to additional surgical procedures. Furthermore, these virtual scenes configurations could also be easily adapted to the surgical and educational methods of other hospitals and integrated into other scenarios that render their operating rooms.

The development of a virtual environment of this nature has required the close collaboration of a multidisciplinary team. The active involvement of the surgeons from the General Surgery Department at Bilbao-Basurto Hospital and undergraduate medical students at UPV/EHU have been crucial for the development of this educational game. As Lie et al. 2023 reported (27), engaging end users in the development process is a key factor for ensuring successful implementation in higher education settings.

## 5. Conclusions

- Immersive technologies, and IVR in particular, is fostering new possibilities for innovation in education and training. Traditional teaching methods are being left behind in favor of didactic and practical training. However, it is important to point out that IVR is a cutting-edge technology that is still in its early stages, and therefore its vast potential remains to be fully realized.

- This virtual development at Bilbao Basurto Integrated Health Organization is expected to be the first of many that will use IVR to train students, professionals and residents at the hospital. It is hoped that this will open up new opportunities, allowing a wide range of procedures and clinical cases to be taught and practiced using virtual reality simulations.

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**Author contributions:** IAM: Protocol/project development, virtual application programming, manuscript writing/editing, data collection. VTG: Protocol/project development, manuscript writing/editing. EPG: surgical room scanning. ALG and AAA: virtual application programming. IVI: data collection. IASR and ALT: Protocol/project development.

## 6. References

1. Sakai D, Joyce K, Sugimoto M, Horikita N, Hiyama A, Sato M, et al. Augmented, virtual and mixed reality in spinal surgery: A real-world experience. *J Orthop Surg* (Hong Kong). **2020**, 28(3). https://doi.org/10.1177/2309499020952698
2. Neher AN, Bühlmann F, Müller M, Berendonk C, Sauter TC, Birrenbach T. Virtual reality for assessment in undergraduate nursing and medical education – a systematic review. *BMC Med Educ*. 2025, 25(1).https://doi.org/10.1186/s12909-025-06867-8
3. Schöbel T, Schuschke L, Youssef Y, Rotzoll D, Theopold J, Osterhoff G. Immersive virtual reality in orthopedic surgery as elective subject for medical students : First experiences in curricular teaching. *Orthopadie* (Heidelberg, Germany). **2024**, 53(5). 369–78. https://pubmed.ncbi.nlm.nih.gov/38575780/
4. Martinez FT, Soto JP, Valenzuela D, González N, Corsi J, Sepúlveda P. Virtual Clinical Simulation for Training Amongst Undergraduate Medical Students: A Pilot Randomised Trial (VIRTUE-Pilot). *Cureus*. **2023**, 5(10). e47527. https://pmc.ncbi.nlm.nih.gov/articles/PMC10663973/

5. Wynn R, Larsen YS, Johannessen K, Solbakken AM. A Virtual Reality Pilot for Second-Year Medical Students' Clinical Training: Students' Experiences. *Stud Health Technol Inform*. **2025**, 323. 516–7. https://ebooks.iospress.nl/doi/10.3233/SHTI250144
6. Pears M, Rochester M, Wadhwa K, Payne SR, Konstantinidis S, Hanchanale V, et al. A Pilot Study Evaluating a Virtual Reality-Based Nontechnical Skills Training Application for Urology Trainees: Usability, Acceptability, and Impact. J Surg Educ. 2023, 80(12). 1836–42. https://pubmed.ncbi.nlm.nih.gov/37723012/
7. Kadri M, Boubakri FE, Hwang GJ, Zahra Kaghat F, Azough A, Alaoui Zidani K. C-IVAL: A Longitudinal Study of Knowledge Retention and Technology Acceptance in Collaborative Virtual Reality-Based Medical Education. *IEEE Access*. **2025**, 13. 16055–71. https://ieeexplore.ieee.org/document/10817604
8. Rizzetto F, Bernareggi A, Rantas S, Vanzulli A, Vertemati M. Immersive Virtual Reality in surgery and medical education: Diving into the future. Vol. 220, *American Journal of Surgery*. **2020**, 856–7. https://doi.org/10.1016/j.amjsurg.2020.04.033
9. Knudsen MH, Breindahl N, Dalsgaard TS, Isbye D, Mølbak AG, Tiwald G, et al. Using Virtual Reality Head-Mounted Displays to Assess Skills in Emergency Medicine: Validity Study. *J Med Internet Res*. **2023**, 25. e45210.https://pmc.ncbi.nlm.nih.gov/articles/PMC10282911/
10. Mergen M, Graf N, Meyerheim M. Reviewing the current state of virtual reality integration in medical education - a scoping review. *BMC Medical Education. 2024*, 24(1). 788. https://link.springer.com/article/10.1186/s12909-024-05777-5
11. Plataforma de desarrollo en tiempo real Unity | Motor 3D, 2D, VR y AR. https://unity.com/es. Accessed: 2025 Dec 3.
12. The enterprise XR platform – VIROO. https://virtualwareco.com/viroo. Accessed: 2025 Dec 3.
13. Meta Quest 3S: Next-gen virtual reality headset | Meta Store. https://www.meta.com/es/en/quest/quest-3s/?srsltid=AfmBOorgzpVUjvg_PVTEQa7AIvxsn-MjaolWRhMmwdAnuEsgH6OAqhHn. Accessed: 2025 Dec 3
14. Kamel Boulos, Susan Toth-Cohen, Simon Bignell et al. Development and Evaluation of Health and Wellness Exhibits. *Journal of Virtual Worlds Research* **2009**, 2, 2. https://jvwr-ojs-utexas.tdl.org/jvwr/article/view/708/502
15. Barteit S, Lanfermann L, Bärnighausen T, Neuhann F, Beiersmann C. Augmented, Mixed, and Virtual Reality-Based Head-Mounted Devices for Medical Education: Systematic Review. *JMIR Serious Games*. **2021**, 9(3), e29080. https://pmc.ncbi.nlm.nih.gov/articles/PMC8299342/
16. Xin B, Chen G, Wang Y, Bai G, Gao X, Chu J, et al. The Efficacy of Immersive Virtual Reality Surgical Simulator Training for Pedicle Screw Placement: A Randomized Double-Blind Controlled Trial. *World Neurosurg.* **2018**, 124, 324–30. https://pubmed.ncbi.nlm.nih.gov/30597280/
17. Liaw SY, Tan JZ, Lim S, Zhou W, Yap J, Ratan R, et al. Artificial intelligence in virtual reality simulation for interprofessional communication training: Mixed method study. *Nurse Educ Today.* **2023**, 122. https://pubmed.ncbi.nlm.nih.gov/36669304/
18. Braun P, Grafelmann M, Gill F, Stolz H, Hinckeldeyn J, Lange AK. Virtual reality for immersive multi-user firefighter-training scenarios. *Virtual Reality & Intelligent Hardware*. **2022**, 4(5). 406–17. https://www.sciencedirect.com/science/article/pii/S209657962200081X
19. Sapkaroski D, Mundy M, Dimmock MR. Immersive virtual reality simulated learning environment versus role-play for empathic clinical communication training. *J Med Radiat Sci.* **2022**, 69(1). 56–65. /doi/pdf/10.1002/jmrs.555
20. Riddle EW, Kewalramani D, Narayan M, Jones DB. Surgical Simulation: Virtual Reality to Artificial Intelligence. *Curr Probl Surg.* **2024**, 61(11). 101625. https://pubmed.ncbi.nlm.nih.gov/39477664/
21. Han SG, Kim YD, Kong TY, Cho J. Virtual reality-based neurological examination teaching tool(VRNET) versus standardized patient in teaching neurological examinations for the medical

students: a randomized, single-blind study. *BMC Med Educ.* **2021**, 21(1). https://pubmed.ncbi.nlm.nih.gov/34526004/

22. Lampropoulos G, del Bosque A, Fernández-Arias P, Vergara D. Virtual Reality in Medical Education, Healthcare Education, and Nursing Education: An Overview. *Multimodal Technologies and Interaction* **2025,** 9(7). 75. https://www.mdpi.com/2414-4088/9/7/75/htm
23. Andersen AG, Rahmoui L, Dalsgaard TS, Svendsen MBS, Clementsen PF, Konge L, et al. Preparing for Reality: A Randomized Trial on Immersive Virtual Reality for Bronchoscopy Training. *Respiration*. **2023**, 102(4). 316–23. www.karger.com/res
24. Lo YT, Yang CC, Yeh TF, Tu HY, Chang YC. Effectiveness of immersive virtual reality training in nasogastric tube feeding education: A randomized controlled trial. **Nurse Educ Today**. *2022*, 119. 105601. https://pubmed.ncbi.nlm.nih.gov/36244254/
25. Klus C, Krumm K, Jacobi S, Willemer MC, Daub C, Stoevesandt D, et al. External post-mortem examination in virtual reality-scalability of a monocentric application. *Int J Legal Med*. **2024**, 138(5). 1939–46. https://pubmed.ncbi.nlm.nih.gov/38592482/
26. Li Pira G, Aquilini B, Davoli A, Silvana G, Ruini C. The Use of Virtual Reality Interventions to Promote Positive Mental Health: Systematic Literature Review. *JMIR Ment Health*. **2023** ,10. 44998. https://pmc.ncbi.nlm.nih.gov/articles/PMC10360019/
27. Lie SS, Helle N, Sletteland NV, Vikman MD, Bonsaksen T. Implementation of Virtual Reality in Health Professions Education: Scoping Review. *JMIR Med Educ*. **2023**, 9. 41589. https://pmc.ncbi.nlm.nih.gov/articles/PMC9906320/