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The Right Recipe for the Metaverse

How the healthcare sector could benefit from virtual worlds

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The metaverse is already driving a gradual change in the healthcare sector. As a multi-sensory environment, this emerging virtual space will generate totally innovative health data that is historically unprecedented in scale and granularity and will significantly enhance machine learning applications. The EU Commission's metaverse strategy should therefore prioritise the healthcare sector and propose a Europe-wide Metaverse TÜV that would uniformly educate users about the technical standards of metaverse health services such as data protection and accessibility.

► The metaverse will create new opportunities for medical professionals and healthcare providers in the areas of education and training, remote communication and telemonitoring, as well as analysis and diagnosis. At the same time, patients will benefit from digital twins, health policy awareness campaigns using editable avatars, pain relief, immersive therapies, virtual counselling as well as "exergaming".

► A European approach to health applications in the metaverse should focus on data protection, accessibility, transparency, security standards as well as human control of monitoring and decision-making. In addition, there are issues of competition and industrial policy that will affect the desired inclusivity of the health system in the metaverse. Precisely because the metaverse, as an integrated, new environment, has to meet certain requirements in terms of data protection and access, which are not sufficiently verifiable either by users or by the competition, an external institution is needed that takes account of the interaction between these factors and sets standards.

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1 Introduction: The Metaverse is coming to Europe

The metaverse - an immersive virtual environment - is a subject that is on everybody's lips. With a global market volume that already exceeded $100 billion last year[1] and could add another $760 billion to US GDP alone by 2035,[2] it will radically change the global economy and society.[3] At least since Facebook founder Mark Zuckerberg renamed his company "Meta", the institutions of the European Union (EU) have also become aware of the issue. Initial ideas for regulating this emerging digital space were put forward at the end of 2022 by Commission President Ursula von der Leyen and Internal Market Commissioner Thierry Breton[4] and outlined by Commission economists.[5] Between April and May 2023, several Citizens' Panels on Virtual Worlds and a first exploratory meeting took place with the aim of creating open, interoperable and innovative virtual worlds based on EU values.[6] A Commission strategy on the metaverse is expected on 11 July, which will bring together the experiences so far gained and probably also specify the initial legislative proposals.[7]

The results of the Citizens' Panel suggest that healthcare should play a central role in the EU's plans with emphasis on physical and mental health as a "cornerstone" for the development and use of virtual worlds in the EU. On that basis, the panel recommended an intensive research programme regarding the impact of virtual worlds on the health of individuals, with mandatory participation of all companies working on this technology. In addition, there was a call for indicators to measure the impact of the use of virtual worlds on social, environmental, psychological and physical health.[8] Picking up on that impulse, this cep**Input** calls for European metaverse plans to focus more strongly on the healthcare sector, as this is where there is great untapped potential: Artificial intelligence (AI)-based medical technologies, which will play a key role in the metaverse, could save around 400,000 lives a year in Europe and save up to € 200 billion.[9] It is no coincidence that, with $ 6.1 billion dollars, healthcare was the AI focus area with the most investments in 2022[10] - and the trend is still rising.[11] In addition to this pure AI, there is the integration of various related technologies, such as augmented reality-based "gamification" or virtual therapy formats, whose interaction gives rise to new types of regulatory requirements.

So although the metaverse promises not only a huge market but also an enormous improvement in quality of life, the subject still seems "a long way off" in this country. Given the repeated complaints about the lack of digitisation in the German healthcare system and the ongoing dispute about digital

1 See Meier, T., Medizinprodukte für das Metaverse, MPR 2022, p. 138.

2 Estimate from: Deloitte, The Metaverse and its Potential for the United States, Final Report (May 2023), p. 4.

3 See also The promise and peril of the metaverse | McKinsey.

4 Blog of Commissioner Thierry Breton (2022), "People, technologies & infrastructure - Europe's plan to thrive in the metaverse", https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_22_5525.

5 DG COMP, "Understanding the metaverse - a competition perspective", https://eaccny.com/news/chapternews/dg-comp-understanding-the-metaverse-a-competition-perspective/.

6 Virtuelle Welten (Metaversen) – eine Vision für Offenheit, Sicherheit und Respekt (europa.eu).

7 "Initiative on virtual worlds".

8 European Citizens' Panel on Virtual Worlds (2023), Final recommendations Virtual Worlds (europa.eu), pp. 2 and 9-10.

9 Deloitte (2020), The socio-economic impact of AI in healthcare (October 2020), mte-ai_impact-in-healthcare_oct2020_report.pdf (medtecheurope.org).

10 Nestor Maslej, Loredana Fattorini, Erik Brynjolfsson, John Etchemendy, Katrina Ligett, Terah Lyons, James Manyika, Helen Ngo, Juan Carlos Niebles, Vanessa Parli, Yoav Shoham, Russell Wald, Jack Clark, and Raymond Perrault, "The AI Index 2023 Annual Report," Institute for Human-Centered AI, Stanford University, Stanford, CA, April 2023, p. 195.

11 We can assume that companies as well as venture capitalists will continue to have a strong incentive to finance the development of medical technology and AI in the context of the metaverse. See also Wang, G. et al. (2022), Development of metaverse for intelligent healthcare, p. 927.

patient records, it is hardly surprising that about 80% of consumers have never heard of a health-related metaverse.[12] This is alarming because Europe is in a global competition for the future of the metaverse that is already - without much "fanfare" - driving change in the healthcare sector.[13] The US FDA is already working on the question of how medical devices could be made usable in the metaverse.[14] Pharmaceutical companies are already using AI for their drug research.[15] Recently, the International Coalition of Medicines Regulatory Authorities noted that new digital technologies are increasingly challenging the regulatory framework.[16] This is even more true in the metaverse, where Western and Chinese regulatory models will compete with each other.[17]

While companies and business consultancies often express a very optimistic view of the economic and social potential of the metaverse, the recommendations of the EU Citizens' Panel seem to predominantly reflect fears and concerns about the new virtual worlds. It is significant that, in their assessments, both proponents and critics of the metaverse all too often lose themselves in abstract discussions and vague forecasts. In deliberate contrast, this cep**Input** sets out specific impacts in the field of healthcare, such as new forms of treatment and therapy, which give a detailed impression of the future possibilities but also the technical and legal hurdles that still exist,[18] because without a more precise idea of what the metaverse is and how it will be used in everyday life, no long-term sustainable regulation at European level is possible. Good regulation of the highly sensitive area of healthcare can only succeed if appropriate applications in the metaverse enjoy the acceptance and trust of patients. This cep**Input** therefore proposes an EU-wide metaverse certification scheme to assess the new situations arising from the interaction between privacy considerations and the competition for health platforms. In addition to better enforcement of existing regulations such as the GDPR, this Metaverse TÜVwould, in light of the sensitivity of metaverse health data, actively conduct vulnerability tests, formulate mandatory standards and most notably consider the combination of diverse technologies.

This argument is substantiated in two stages. Section 2 begins with a description of the impact of the metaverse on the healthcare sector and focusses on providing as broad an overview as possible and a technical introduction to the state of research in this regard. On that basis, Section 3 summarises the opportunities and risks for Europe and proposes the introduction of a new Metaverse TÜV to prepare the European healthcare system for the metaverse. Instead of analysing the extent to which existing individual legal acts correspond or conflict with the potential of the metaverse in healthcare, we consider on a conceptual level what conditions must be created by policy to ensure that the examples mentioned (and many others!) do actually become a reality for care in ten to twenty years' time. In this regard, data protection and broad accessibility turn out to be the most important conditions.[19] The link between data protection and competition issues, which could arise from data and distribution monopolies caused by market entry barriers in the metaverse, is precisely what suggests that both issues should be covered by an holistic Metaverse TÜV.

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12 See BearingPoint (2022), Revolution des Gesundheitswesens – Healthcare Metaverse ist keine Zukunftsmusik mehr.
13 See also BCG (2023), The Health Care Metaverse Is More Than a Virtual Reality.
14 See Meier, T., Medizinprodukte für das Metaverse, MPR 2022, p. 134.
15 Thus, e.g. AstraZeneca; Data Science & Artificial Intelligence: Unlocking new science insights (astrazeneca.com).
16 horizon_scanning_report_artificial_intelligence.pdf (icmra.info).
17 metaverse-paper-9-march-2022.pdf (europa.eu), p. 9.
18 Brief summary already provided by: Vigkos, A., Bevacqua, D., Turturro, L., et al., VR/AR Industrial Coalition: strategic paper, Publications Office of the European Union, 2022, p. 17.
19 For the Citizens' Panel, see also: Gray, P. (2023), Wisdom of the Crowd pt. 3, Metaverse.EU (metaversepolicy.eu).

2 The implications of the metaverse for the healthcare sector

The healthcare sector lends itself to a case study on the impact of the metaverse because virtual medical services, such as telemedicine, have become increasingly popular since the Covid pandemic and thus initial use cases and field reports are already available. Even those who are sceptical about the concept of a metaverse admit that its underlying technical innovations have potential for medicine and healthcare in particular, often citing mental health counselling.[20] Positive experience, gained in the field of online psychological counselling in recent years, raises the question of how metaverse technologies can be used to improve the treatment of diseases without exacerbating existing dangers or inequalities.[21]

While this study was being prepared, a group of researchers commissioned by the EU presented an initial, cautiously optimistic report on the use of virtual reality technology, looking, among other things, at the field of healthcare.[22] The researchers describe how the technology can be used to assist with surgery or to rehabilitate patients. At the same time, a number of barriers are also pointed out, including low social acceptance, a lack of qualified experts and the current state of development of the devices. In addition, the study emphasises that potential negative effects of the technology still need to be better researched. From a conceptual perspective, the researchers' analysis focuses on so-called Extended Reality (XR) in healthcare. The scope thus includes augmented reality (AR), virtual reality (VR) and mixed reality (MR) technologies, collectively referred to as XR. By way of context: The German XR industry numbered a total of 1,613 mostly medium-sized companies in 2022.[23]

However, the concept of the metaverse involves much more than a partial use or development of individual AR, VR or MR technologies; it essentially refers to an immersive virtual environment that can be accessed by various means and literally "draws" the user - with all their sensory perceptions - into it. As defined by technology expert and investor Matthew Ball, the metaverse is "a massively scaled and interoperable network of real-time rendered 3D virtual worlds that can be experienced synchronously and persistently by a virtually unlimited number of users, with an individual sense of presence and with continuity of data, such as identity, history, entitlements, objects, communications and payments".[24] This definition is also used by the in-house analysis and research team for the Council of the EU.[25]

In line with this broad perspective, we propose to go beyond case studies that describe the complementary benefits of individual AR or VR devices, for existing, i.e. physical hospital or training experiences, such as the use of AR as a surgical navigation system.[26] Although such incremental improvements will save lives and should not be underestimated, this narrow perspective fails to recognise the potential of the metaverse to create new, cheaper and more democratic ways of

[20] Pew Research Center Report, The Metaverse in 2040.

[21] Politico's Digital Future Daily, 14 Dec 2022, Mental health in the metaverse.

[22] European Commission, Directorate-General for Communications Networks, Content and Technology, Boel, C., Dekeyser, K., Depaepe, F., et al, Extended reality : opportunities, success stories and challenges (health, education) : final report, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2759/121671.

[23] XR-Studie Deutschland 2022, p. 6.

[24] Ball, Matthew, The Metaverse: And How It Will Revolutionize Everything, Liveright Publishing Corporation, 2022, p. 57.

[25] metaverse-paper-9-march-2022.pdf (europa.eu), p. 3.

[26] By integrating real-time tracking, the surgical interface can be enhanced with virtual images of critical structures. Chan HHL, Haerle SK, Daly MJ, Zheng J, Philp L, Ferrari M, et al. (2021) An integrated augmented reality surgical navigation platform using multi-modality imaging for guidance. PLoS ONE 16(4): e0250558.

accessing healthcare, as well as to develop improved diagnostic and therapeutic options. As a multi-sensory environment, the metaverse will generate a multitude of new health-related data, that will be historically unprecedented in scale and granularity and will enhance machine learning applications. Thus, for example, in the metaverse, VR can be combined with biofeedback, such as heart rate monitoring, and with neurofeedback. There are already prototypes for immersive virtual worlds that can automatically recognise and specifically evoke various emotions from the neuronal and cardiac data of users - i.e. their brain waves and heart activities- in combination with AI.[27]

Fig. 1: Impact of the metaverse on the health sector - two dimensions

Source: Own representation.

The impact of this holistic understanding of the metaverse for the healthcare sector can be roughly divided into two different areas depending on the user group (Figure 1). On the one hand, the metaverse will create new opportunities for medical practitioners and medical companies, for example by enabling new forms of diagnostics that go far beyond what is currently possible in the physical world (Section 2.1). On the other hand, the metaverse will also open up new ways for users, i.e. patients and the general population, to access health services that are unprecedented in their scope and efficiency (section 2.2).

In summary: Based on Matthew Ball's definition, we would like to focus on the health-related aspects in an immersive metaverse, asking the more fundamental question: What will it mean for the healthcare system and its regulation if the majority of the population moves in the metaverse, creating a huge treasure trove of new data that enables innovative methods of diagnosis and therapy, but also poses challenges in terms of data protection? In other words: We are concerned with the implications of the metaverse itself, rather than the specific devices such as headsets or

[27] Marín-Morales, J., Higuera-Trujillo, J.L., Greco, A. et al. Affective computing in virtual reality: emotion recognition from brain and heartbeat dynamics using wearable sensors. Sci Rep 8, 13657 (2018).

smartphones used to access this real-time rendered world. All too often, such discussions about the metaverse and its possible advantages, disadvantages and regulatory needs get bogged down at an abstract level without looking at concrete use cases.[28] This section aims to fill this gap and provide an overview of various studies, technologies and fields of application that give an idea of how the metaverse could revolutionise healthcare - if the right framework conditions are put in place.

2.1 Applications for professionals and medical companies

The metaverse will create new opportunities for medical professionals and medical companies in the areas of education and training, remote communication and telemonitoring, as well as analysis and diagnosis.

Education and training

It is already possible to use XR technologies to complement education, training and professional development in the real world.[29] This could also of course be applied in a similar way in medical training, e.g. by using more 3-D simulations to explore the human body.[30] But the potential extends beyond these gradual improvements. Since there are fewer and fewer opportunities to practice with real patients, and medical professionals increasingly need to offer virtual consultations, the demand for more advanced, realistic simulation methods will continue to grow in the coming years.[31] Against this backdrop, the metaverse opens up new ways to train medical staff virtually, immersively and in a low-resource setting. Virtual worlds enable repetitive practice in various medical disciplines without adverse effects on patients; they open up new ways of learning complex medical content and reduce the financial, ethical and legal constraints applicable to the use of traditional learning materials such as cadavers. A meta-analysis of previous studies in this area found that medical training in AR and VR-based environments was seen as particularly salient, motivating and effective.[32]

Remote communication and telemonitoring

This training aspect, which has been the focus of previous reports on the potential of XR technologies for healthcare, is only the first step. The virtual presence of medical professionals in the metaverse gives them a global reach, which means that new forms of **remote communication and telemonitoring** will emerge. Specialist surgeons and other experts can share their exceptional knowledge in graphic manner, in the metaverse, without having to travel.[33] The same applies to the sharing of expertise. The idea itself is not new and is already successfully practised in Europe without

[28] For example, in his widely cited book "The Metaverse", Matthew Ball explains how the implementation of metaverse technologies could work in practice. He also explicitly mentions medicine and healthcare as a promising area of application, but does not go into detail. Matthew Ball, The Metaverse: And How It Will Revolutionize Everything, Liveright, p. 268.

[29] For example, US companies have already developed AR exercises for first responders which can be used to train them cost-effectively and without the need for travel. Lajara, C. (2023), [Colorado police force uses augmented reality to train officers for dangerous scenarios (kktv.com)] (31.01.2023).

[30] See also: Matthew Ball, The Metaverse: And How It Will Revolutionize Everything, Liveright, p. 268.

[31] Zweifach, S.M., Triola, M.M. Extended Reality in Medical Education: Driving Adoption through Provider-Centered Design. Digit Biomark. 2019 Apr 10;3(1):14-21.

[32] 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 Jul 8;9(3):e29080.

[33] Vigkos, A., Bevacqua, D., Turturro, L., et al., VR/AR Industrial Coalition: strategic paper, Publications Office of the European Union, 2022, p. 17.

VR/AR.[34] European Reference Networks (ERNs) are virtual networks of European healthcare providers that facilitate discussions on rare diseases and highly specialised treatments. However, the ability to meet in the metaverse could allow for this exchange to be intensified, made more effective and enable the latest findings and knowledge to be shared more quickly, all in the interests of the patients. For example, thanks to head-mounted VR and AR displays, medical teams can more easily share data and at the same time analyse 3D medical images.[35] This reduces the number of meetings required, for example, before an operation.

Telementoring goes beyond this communication aspect and forms part of telemedicine, as it involves remote care by a specialist or surgeon. AR systems with low-latency - the delay between starting an action in the metaverse and the point at which the corresponding avatar reflects that action - immediately show the mentor what the local surgeon can see at that moment, while the mentor's advice is displayed directly in the surgeon's field of vision.[36] This will particularly benefit specialties where visual inspection is required, such as injury assessment, patient monitoring and trauma care.[37]Telementoring is a secure option for providing specialist diagnoses and opinions, reducing the likelihood of incorrect treatment and unnecessary patient referrals.[38] Tele-surgery goes a step further, as it involves the remote control of a surgical robot and therefore falls outside the context of this investigation (as it ultimately relates more to the physical world), but it is worth mentioning that successful feasibility studies have already been carried out in this regard which emphasise the great potential for remote rural areas.[39]

Analysis and diagnosis of patients

The new data generated in the metaverse offers greater accuracy and efficiency than conventional medical analysis and diagnostic techniques. While so far most discussions have referred to improved diagnosis by way of high-resolution microscopic 3D images of patients' anatomy,[40] we emphasise a more fundamental point, namely that the metaverse will enable **improved analysis and diagnosis of patients** when they are in virtual settings where they can be observed. In concrete terms, the metaverse will create a virtual 3D environment, which can be entered using a commercially available VR display, and in which common patient assessment tasks can be emulated, such as fixating on a specific point, steadily tracking an object or performing so-called saccades (very fast and short movements of the eyeball).[41]

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34 See: https://health.ec.europa.eu/european-reference-networks/overview_en.

35 Microsoft HoloLens, Magic Leap and Google Glass come to mind, for example.

36 Hamacher A, Kim SJ, Cho ST, Pardeshi S, Lee SH, Eun SJ, Whangbo TK. Application of Virtual, Augmented, and Mixed Reality to Urology. Int Neurourol J. 2016 Sep;20(3):172-181.

37 Khor WS, Baker B, Amin K, Chan A, Patel K, Wong J. Augmented and virtual reality in surgery-the digital surgical environment: applications, limitations and legal pitfalls. Ann Transl Med. 2016 Dec;4(23):454.

38 Gardiner S, Hartzell TL. Telemedicine and plastic surgery: a review of its applications, limitations and legal pitfalls. J PlastReconstrAesthetSurg 2012;65:e47-53.

39 Remote surgery is now routinely used in the USA, providing rural patients with high quality laparoscopic surgical services and a high degree of collaboration between surgeons in teaching hospitals and rural hospitals. See: Anvari M, McKinley C, Stein H. Establishment of the world's first telerobotic remote surgical service: for provision of advanced laparoscopic surgery in a rural community. Ann Surg. 2005 Mar;241(3):460-4.

40 See e.g.: [How AR & VR can transform healthcare (linkedin.com)](https://linkedin.com).

41 Orlosky J, Itoh Y, Ranchet M, Kiyokawa K, Morgan J, Devos H. Emulation of Physician Tasks in Eye-Tracked Virtual Reality for Remote Diagnosis of Neurodegenerative Disease. IEEE Trans Vis Comput Graph. 2017 Apr;23(4):1302-1311.

Collecting and quantifying these observations as digital data in the metaverse is key because a patient's medical evaluation - such as neuropsychological eye tests - depends significantly on test conditions such as room lighting. These conditions limit standardisation, compromise reliability and prevent the evaluation of core functions such as visual processing speed. The VR devices used to access the metaverse make it possible to solve these problems because they are worn on the head and thus cover the entire field of vision, shielding and standardising visual stimulation. In tests, researchers found that a headset already available today is suitable for the standardised and reliable assessment and diagnosis of elementary cognitive functions in the laboratory and clinic.[42] Similarly, researchers were able to use VR glasses and virtual image recognition tasks to quantify a patient's level of amblyopia, a condition in which input from one eye is suppressed by the brain.[43] This was not previously possible using conventional methods in the physical world.

In another case, a team of researchers used a combination of VR games, eye tracking and AI methods to show how differences in eye movements can be used to detect attention deficit disorder (ADHD) in children.[44] The researchers, from Aalto University, Helsinki University and ÅboAkademi University, developed a VR game called "EPELI" for this purpose, which simulates everyday actions such as brushing teeth. The analysis shows that the gaze of ADHD children lingers longer on different objects in the environment and that their gaze jumps faster and more frequently from one point to another. This approach could also be used to assess other conditions, such as autism, in the metaverse.[45]

The greatest potential of the new metaverse data in terms of analysis and diagnosis is probably in the area of certain **mental, neurological and cognitive disorders**. With such disorders, it is often difficult to place the patient in real-life scenarios where the relevant behaviours can be evaluated. In addition, conventional clinical questionnaires can give rise to biased results. By contrast, the metaverse provides a secure platform to recreate real-life situations using interactive virtual simulations in which patient behaviour and reactions can be closely observed and recorded. A meta-study examining various VR environments found that they could reliably elicit and measure relevant psychiatric symptoms and that these VR measures showed statistically significant correlations with traditional diagnostic measures, i.e. were generally consistent.[46] Disorders commonly studied using VR are schizophrenia, developmental disorders, eating disorders and anxiety disorders. In addition, VR can be used to diagnose cognitive dysfunctions in spatial navigation,[47] neurodegenerative diseases such as Parkinson's disease,[48] behavioural addictions[49] and social anxiety.[50]

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[42] They used Oculus Rift. See: Foerster RM, Poth CH, Behler C, Botsch M, Schneider WX. Using the virtual reality device Oculus Rift for neuropsychological assessment of visual processing capabilities. Sci Rep. 2016 Nov 21;6:37016.

[43] Panachakel JT, Ramakrishnan AG, Manjunath KP. VR Glasses based Measurement of Responses to Dichoptic Stimuli: A Potential Tool for Quantifying Amblyopia? Annu Int Conf IEEE Eng Med Biol Soc. 2020 Jul;2020:5106-5110.

[44] ADHD is a neurodevelopmental disorder characterised by excessive levels of inattention, hyperactivity and impulsivity.

[45] Merzon, L., Pettersson, K., Aronen, E.T. et al. Eye movement behavior in a real-world virtual reality task reveals ADHD in children. Sci Rep 12, 20308 (2022). https://doi.org/10.1038/s41598-022-24552-4. See also reports in: McFarland, A. (2022), VR Could Help Detect ADHD in Children - Unite.AI (December 30, 2022).(2022), VR Could Help Detect ADHD in Children - Unite.AI (December 30, 2022).

[46] van Bennekom, M. J., de Koning, P. P., & Denys, D. (2017). Virtual reality objectifies the diagnosis of psychiatric disorders: A literature review. Frontiers in Psychiatry, 8, Article 163.

[47] Cogné M, Taillade M, N'Kaoua B, Tarruella A, Klinger E, Larrue F, Sauzéon H, Joseph PA, Sorita E. The contribution of virtual reality to the diagnosis of spatial navigation disorders and to the study of the role of navigational aids: A systematic literature review. Ann Phys Rehabil Med. 2017 Jun;60(3):164-176.

[48] Orlosky J, Itoh Y, Ranchet M, Kiyokawa K, Morgan J, Devos H. Emulation of Physician Tasks in Eye-Tracked Virtual Reality for Remote Diagnosis of Neurodegenerative Disease. IEEE Trans Vis Comput Graph. 2017 Apr;23(4):1302-1311.

Virtual worlds thus offer non-invasive, non-pharmacological and easier-to-use observation and intervention environments to make diagnoses. However, a review of existing applications of VR technology using the example of Alzheimer's diagnoses found that most current applications do not yet fully exploit the advantages of virtual worlds - namely the high degree of immersion and interaction.[51] For example, most still rely on conventional 2D graphic displays. The introduction of a realistic, multisensory metaverse that enables biofeedback therefore still promises to bring numerous qualitative improvements.

In summary: According to initial research, when patients are medically examined in a virtual world, they are fully immersed in the metaverse, and not therefore distracted by external factors as they would be in a physical examination room, thus allowing the doctor to record a patient's symptomsmore accurately.The introduction of health services in the metaverse thus allows empirical manipulation of the information brought into the virtual environment, thereby giving rise to better diagnoses than the equivalent expensive, laborious, lengthy and ultimately error-prone clinical studies. This, however, requires a high level of patient trust in the technology, especially regarding the use of such sensitive data - a point we will return to several times. Moreover, initial statistical studies suggest that virtual manipulations vary in effectiveness depending on their nature and the respective user group.[52] Thus, more research is needed to find out what kind of data and virtual formats are most efficient for reliable diagnoses - other data that is not relevant would not then need to be stored in the first place.

2.2 Effects of the metaverse on patients and the population

In addition to the efficiency-boosting applications for medical professionals and specialists, there will also be numerous positive effects for users of the metaverse, i.e. patients and the population in general. This includes enhanced distribution of information using digital twins, raising awareness of health policy using avatars, pain relief and immersive therapies, virtual counselling, and so-called "exergaming", which increases disease prevention and invalidates the stereotype that digitalisation only promotes unhealthy behaviour.

Digital twins

Firstly, the metaverse will enable patients to better understand various aspects of their own health as well as the healthcare system by rendering and visualising this information by way of a so-called **digital twin**. In healthcare, the term refers to all digital models that are based on a medical data set and can thus visualise, simulate and optimise medical processes. Like the plans for an Industry 4.0, the ideal metaverse scenario would therefore be the creation of a personalised digital twin for each

[49] Segawa T, Baudry T, Bourla A, Blanc JV, Peretti CS, Mouchabac S, Ferreri F. Virtual Reality (VR) in Assessment and Treatment of Addictive Disorders: A Systematic Review. Front Neurosci. 2020 Jan 10;13:1409.

[50] Dechant, Martin Johannes, Sabine Trimpl, Christian Wolff, Andreas Mühlberger and Youssef Shiban. “Potential of virtual reality as a diagnostic tool for social anxiety: A pilot study.” Comput. Hum. Behav. 76 (2017): 128-134.

[51] García-Betances, R. I., Waldmeyer, M. T. A., Fico, G., & Cabrera-Umpiérrez, M. F. (2015). A succinct overview of virtual reality technology use in Alzheimer’s disease. Frontiers in Aging Neuroscience, 7, Article 80.

[52] Cogné M, Taillade M, N'Kaoua B, Tarruella A, Klinger E, Larrue F, Sauzéon H, Joseph PA, Sorita E. The contribution of virtual reality to the diagnosis of spatial navigation disorders and to the study of the role of navigational aids: A systematic literature review. Ann Phys Rehabil Med. 2017 Jun;60(3):164-176.

patient to simulate medical diagnoses and treatments in a virtual environment.[53] Patients could use these digital twins in the metaverse, for example, to get an enhanced or virtual picture of what to expect during an operation. This would improve documentation and communication, which ultimately affects the quality of services and patient safety.[54] Viewing and experiencing VR-based previews of surgery may also upgrade the provision of informed consent for surgical procedures. Experimental results suggest that immersive 3D-assisted informed consent improves patients' understanding of their condition without increasing their anxiety.[55]

Finally, digital twins that go beyond the mapping of a patient and encompass other aspects of healthcare are also conceivable. For example, the virtual hospital project enabled pregnant women to make a virtual visit to the maternity ward of a hospital in order to plan the various stages of their subsequent hospital visit and reduce their fear of giving birth.[56] In this context, it should also be mentioned that patients can undertake thorough and safe prosthesis training in the metaverse. The current rejection rate of adult prostheses is high, but VR-based training methods increase the likelihood of patients making full, long-term use of prostheses.[57]

All the aforementioned applications are essentially based on the possibilities that arise from creating a digital twin of the planned operation, hospital or prosthesis, which patients can view, try out and experience immersively in the metaverse. This, however, requires trust in the underlying technology; an aspect already emphasised in relation to the applications for medical professionals. So, although the current stage of technological development still suffers from difficulties regarding data collection, data fusion and accurate simulation, it is likely that digital twins in the metaverse will evolve into a new platform for personal health management and health services.[58]

Raising awareness

Furthermore, the metaverse will enable greater **awareness** of health issues by allowing users to adopt a virtual body that differs from their physical body. It is not therefore an identical digital twin, as discussed in the previous section, but a so-called avatar that can be customised as desired. This can be used, for example, to simulate how it feels to live with a certain disease. Thus, the metaverse can improve the understanding and empathy of carers and better educate the public. For example, VR interventions have been shown to help informal carers of dementia patients who often suffer psychologically due to the rapid changes that take place in the person they are caring for. By experiencing a virtual simulation of their own dementia, participants in a pilot study significantly improved their empathy, their confidence in caring for the dementia sufferer and their ability to

[53] Lecture by Prof. David Matusiewicz on 24 February 2023 at the "Young Inflammation" event organised by the Rheumazentrum Rhein Ruhr at the Heinrich-Heine-Universität Düsseldorf.

[54] Khor WS, Baker B, Amin K, Chan A, Patel K, Wong J. Augmented and virtual reality in surgery-the digital surgical environment: applications, limitations and legal pitfalls. Ann Transl Med. 2016 Dec;4(23):454.

[55] Perin A, Galbiati TF, Ayadi R, Gambatesa E, Orena EF, Riker NI, Silberberg H, Sgubin D, Meling TR, DiMeco F. Informed consent through 3D virtual reality: a randomized clinical trial. Acta Neurochir (Wien). 2021 Feb;163(2):301-308.

[56] Discover our latest work | Poppr.

[57] Gaballa, Aya & Cavalcante, Reidner & Lamounier Jr, Edgard & Soares, Alcimar&Cabibihan, John-John. (2022). Extended Reality “X-Reality” for Prosthesis Training of Upper-Limb Amputees: A Review on Current and Future Clinical Potential. IEEE Transactions on Neural Systems and Rehabilitation Engineering. 10.1109/TNSRE.2022.3179327.

[58] Sun T, He X, Song X, Shu L, Li Z. The Digital Twin in Medicine: A Key to the Future of Healthcare? Front Med (Lausanne). 2022 Jul 14;9:907066.

interact with them.[59] Another example concerns visual impairment: Researchers concluded that modern digital simulators, such as those that can be used to access the metaverse, are able to reproduce and objectively quantify some of the main everyday difficulties associated with visual impairment.[60] More generally, a virtual body can help to better identify inherent attitudes and perceptions and thereby overcome prejudices,[61] which is crucial to the long-term health of the population in a much broader sense.

Pain relief

Being embedded in an immersive metaverse that blocks out the environment can significantly reduce a person's ability to respond to neural signals. In other words, the immersive nature of the metaverse can be used in healthcare to distract from pain. Since immersive experiences in the metaverse alter the perception of pain, they can be used as an effective non-pharmacological tool to **relieve acute and chronic pain** .[62] According to one study, burn patients who actively engaged in a VR game had significantly less pain than other patients during wound care (with statistical analysis taking account of criteria such as age, gender, pain before the procedure, anxiety, opiate use and treatment duration).[63] Of particular interest in this study was the finding that a more passive distraction of watching a movie was less effective in reducing pain, which in turn suggests a real added value from new metaverse technologies. In the USA, there are already children's hospitals that use VR/AR for pain management and have been able to reduce the need for anaesthesia and physiotherapy.[64]

A systematic review of previous studies and applications in this area found statistically significant results for pain relief and improvement in functional capacity as a result of intervention with VR technology.[65] These results suggest that metaverse experiences could be used not only for acute pain management but also in the treatment of chronic pain. Thus, the increasing affordability and quality of wearable VR headsets and the continuing benefits of pain management suggest great potential for the metaverse regarding this type of healthcare service. However, further research is needed to establish the long-term benefits if metaverse-based experiences are to be incorporated into mainstream pain management protocols.

Virtual therapy

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59 Wijma EM, Veerbeek MA, Prins M, Pot AM, Willemse BM. A virtual reality intervention to improve the understanding and empathy for people with dementia in informal caregivers: results of a pilot study. Aging Ment Health. 2018 Sep;22(9):1115-1123.

60 Jones, P.R., Somoskeöy, T., Chow-Wing-Bom, H. et al. Seeing other perspectives: evaluating the use of virtual and augmented reality to simulate visual impairments (OpenVisSim). npj Digit. Med. 3, 32 (2020). https://doi.org/10.1038/s41746-020-0242-6.

61 Chen Vivian Hsueh Hua, Ibasco Gabrielle C., Leow Vetra Jing Xuan, Lew Juline Yun Yee (2021), The Effect of VR Avatar Embodiment on Improving Attitudes and Closeness Toward Immigrants, Frontiers in Psychology 12, Frontiers | The Effect of VR Avatar Embodiment on Improving Attitudes and Closeness Toward Immigrants (frontiersin.org).

62 Ahmadpour N, Randall H, Choksi H, Gao A, Vaughan C, Poronnik P. Virtual Reality interventions for acute and chronic pain management. Int J Biochem Cell Biol. 2019 Sep;114:105568.

63 Jeffs D, Dorman D, Brown S, Files A, Graves T, Kirk E, Meredith-Neve S, Sanders J, White B, Swearingen CJ. Effect of virtual reality on adolescent pain during burn wound care. J Burn Care Res. 2014 Sep-Oct;35(5):395-408.

64 Pew Research Center Report, The Metaverse in 2040.

65 Goudman L, Jansen J, Billot M, Vets N, De Smedt A, Roulaud M, Rigoard P, Moens M. Virtual Reality Applications in Chronic Pain Management: Systematic Review and Meta-analysis. JMIR Serious Games. 2022 May 10;10(2):e34402.

The metaverse can also be used to provide **virtual therapy**. A recent meta-study has provided evidence for the positive effect of VR therapy on psychiatric disorders.[66] Incorporating VR into therapy can increase the ease, acceptance and efficacy of treatments for anxiety disorders. VR exposure therapy allows for personalised, step-by-step, controlled and immersive exposure that is easy for therapists to implement, and often more acceptable to patients than in vivo or imaginal exposure.[67] The metaverse thus offers an opportunity to improve both access to, and the efficacy of, exposure therapy. As mentioned above, VR or AR-based therapy can also be more entertaining than the normal exercises, which may improve user motivation and engagement. On balance, therapy in the metaverse appears to be more acceptable and potentially more effective than conventional therapy.

And there are already some relevant studies and examples of this application. For example, finding and destroying cigarettes in a game-like environment can help people to kick their smoking habit.[68] VR can be used in the rehabilitation of patients with orientation disorders.[69] Eating disorders can also be treated in the metaverse, as studies have shown that virtual foods evoke the same emotional reactions in patients as real foods.[70] Researchers have developed a tailored, controlled and empirically validated VR-based body exposure therapy to help patients manage their fear of weight gain.[71] Experimental AR systems are being tested in many different ways for stroke rehabilitation, but further investigation is needed here.[72] Finally, VR-assisted neurorehabilitation can also be applied in the areas of motor function, sensory-motor function and cognition.[73]

Further applications for the metaverse arise from the combination of VR and AI, which can be used together in such a way as to trigger hallucinatory effects in the brain.This could be used, to develop substitution therapy for certain drugs as well as completely new types of treatment based on VR/AI hallucinatory effects. The latter could significantly reduce the use of psychotropic drugs or even make them obsolete. A recent study found that participants were more cognitively flexible or adaptive after experiencing a simulated hallucination. In this study, participants' cognitive flexibility was measured using behavioural tasks in a VR environment, with hallucinatory drug counterparts

66 Cieślik B, Mazurek J, Rutkowski S, Kiper P, Turolla A, Szczepańska-Gieracha J. Virtual reality in psychiatric disorders: A systematic review of reviews. Complement Ther Med. 2020 Aug;52:102480.

67 Boeldt D, McMahon E, McFaul M, Greenleaf W. Using Virtual Reality Exposure Therapy to Enhance Treatment of Anxiety Disorders: Identifying Areas of Clinical Adoption and Potential Obstacles. Front Psychiatry. 2019 Oct 25;10:773.

68 Pericot-Valverde I, Secades-Villa R, Gutiérrez-Maldonado J, García-Rodríguez O. Effects of systematic cue exposure through virtual reality on cigarette craving. Nicotine Tob Res. 2014 Nov;16(11):1470-7.

69 Cogné M, Taillade M, N'Kaoua B, Tarruella A, Klinger E, Larrue F, Sauzéon H, Joseph PA, Sorita E. The contribution of virtual reality to the diagnosis of spatial navigation disorders and to the study of the role of navigational aids: A systematic literature review. Ann Phys Rehabil Med. 2017 Jun;60(3):164-176.

70 Riva, G, Malighetti, C, Serino, S. Virtual reality in the treatment of eating disorders. Clin PsycholPsychother. 2021; 28: 477– 488.

71 Porras-Garcia B, Ferrer-Garcia M, Serrano-Troncoso E, Carulla-Roig M, Soto-Usera P, Miquel-Nabau H, Olivares LFC, Marnet-Fiol R, Santos-Carrasco IM, Borszewski B, Díaz-Marsá M, Sánchez-Díaz I, Fernández-Aranda F, Gutiérrez-Maldonado J. AN-VR-BE. A Randomized Controlled Trial for Reducing Fear of Gaining Weight and Other Eating Disorder Symptoms in Anorexia Nervosa through Virtual Reality-Based Body Exposure. J Clin Med. 2021 Feb 10;10(4):682.

72 Gorman C, Gustafsson L. The use of augmented reality for rehabilitation after stroke: a narrative review. DisabilRehabil Assist Technol. 2022 May;17(4):409-417.

73 Ku, J., & Kang, Y.J. (2018). Novel Virtual Reality Application in Field of Neurorehabilitation. [PDF] Novel Virtual Reality Application in Field of Neurorehabilitation | Semantic Scholar.

being generated by an algorithm. The results suggest that simulated altered perceptual phenomena do indeed produce concrete effects, such as increased cognitive flexibility.[74]

Another concrete application of the metaverse for treating patients comes from the Scandinavian ADHD study mentioned above, which used a VR game, eye tracking and machine learning to show how differences in eye movements can be used to detect ADHD. The new approach could be used not only to detect ADHD, but also for ADHD therapy and the treatment of other disorders and, according to the researchers involved, the experience so far has been very positive.[75] Thus, to put it in more general terms, the metaverse facilitates digital therapy based on games *(gamification-based digital therapy*).

Virtual counselling

Additional important conclusions regarding the treatment of patients arise from the aforementioned boom in telemedicine services during the pandemic. The reasons for this boom are important when considering the long-term implications of the metaverse on the health sector. For example, recent surveys have shown that more than half of people now prefer online visits rather than in-person treatment.[76]In addition, 94% of telemedicine users stated that they "definitely will" or "probably will" make use of medical services via telemedicine again in the future. The main reasons for using such online services were convenience (61%), the ability to get treated quickly (49%) and easy access to health information (28%).[77]

The willingness to access psychological counselling online during the pandemic thus opens up the question of how the metaverse could be used to treat psychological illness, and more generally for **counselling services**. In answering this question, the social aspects of technology appear to be particularly relevant. For example, researchers found that people who communicated in virtual worlds rather than in conventional 2D online formats - such as video consultations or zoom rooms - felt more like they were physically present. Socialisation activities, such as meeting friends in a VR environment, were associated with relatedness and enjoyment. These results, based on a survey of 220 participants, provide a first quantitative assessment of the potential positive impact of the metaverse on the broader well-being of patients and the population.[78]

In principle, these results are unsurprising, given the experience that users and researchers have already gained over the past decade from the online environment "Second Life" which is a kind of proto-metaverse. In Second Life, users create a digital avatar to represent them and can then explore the world, meet other users and even trade. Second Life experienced its commercial peak in the late noughties, and its blocky graphics as well as the keyboard and mouse controls that were required at the time, are a far cry from the current Mark Zuckerberg vision of a metaverse based on expensive

[74] Rastelli, C., Greco, A., Kenett, Y.N. et al. Simulated visual hallucinations in virtual reality enhance cognitive flexibility. Sci Rep 12, 4027 (2022). https://doi.org/10.1038/s41598-022-08047-w.

[75] Merzon, L., Pettersson, K., Aronen, E.T. et al. Eye movement behavior in a real-world virtual reality task reveals ADHD in children. Sci Rep 12, 20308 (2022). https://doi.org/10.1038/s41598-022-24552-4. For the experiences see: McFarland, A. (2022), VR Could Help Detect ADHD in Children - Unite.AI (December 30, 2022).

[76] The figures are based on the J.D. Power 2022 U.S. Telehealth Satisfaction Study.

[77] Hagen, J. (2022), Survey: Consumers prefer telehealth over in-person visits for routine, mental healthcare | MobiHealthNews (September 29, 2022).

[78] Barreda-Ángeles M, Hartmann T. Psychological benefits of using social virtual reality platforms during the covid-19 pandemic: The role of social and spatial presence. Comput Human Behav. 2022 Feb; 127:107047.

VR headsets. Nevertheless, Second Life is probably the longest running experiment of a metaverse-like experience[79] which is helpful because studies now exist that have examined the psychological benefits of using Second Life.[80] The extent to which the virtual experiences in Second Life addressed psychological needs, such as belonging, esteem and self-fulfilment, and led to an increase in autonomy, competence, connectedness, moderation and security suggests that the metaverse will have at least an equal benefit in the field of psychological counselling. Already, people suffering from insomnia or loneliness put on their headsets and gather in VR dormitories that offer relaxation and companionship among people unknown to each other.[81] Others attend meetings to discuss bereavement and death.[82] The combination of anonymity and togetherness in the metaverse thus enables intensive and productive virtual contact, which at the same time avoids many of the social tensions that arise in classic doctor-patient relationships.

So, overall, the metaverse offers enormous and rapidly evolving possibilities for **virtual counselling** for people suffering from anxiety, stress, or significant psychological distress. Empirical results suggest that the use of digital psychological intervention to reduce psychological stress in the population during the pandemic was successful.[83] In the future, the metaverse may thus contribute to counteracting loneliness, improving connectedness and providing intellectual stimulation for older adults in assisted living communities.[84] In addition, the metaverse has been shown to provide many new ways to access medical information or participate in medical therapy, especially for disadvantaged or physically impaired people. Nevertheless, there is still a need for further investigation in this regard: Two elements of the so-called therapeutic alliance, namely agreement on goals and tasks, can be easily achieved in the virtual context; the third element, the quality of the relationship, on the other hand, is still questionable.[85]

Exergaming

Finally, the metaverse can be used for motor development and preventive health policy, especially in children with neurological movement disorders.[86] So-called **exergaming** refers to physical exercise associated with video game activities, traditionally using digital hardware - for example, the Wii or Xbox. The metaverse provides an engaging, immersive environment for such exergaming techniques which boost patient autonomy and maximise targeted training. For example, VR was shown in one study to increase the enjoyment of exercise, and children preferred exercising in virtual environments. This distraction effect of VR was more pronounced in overweight children than in

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79 See also: Gent, E. (2021), What Can the Metaverse Learn From Second Life? - IEEE Spectrum (29 November 2021).

80 For an overview, see: Barreda-Ángeles M, Hartmann T. Psychological benefits of using social virtual reality platforms during the covid-19 pandemic: The role of social and spatial presence. Comput Human Behav. 2022 Feb; 127:107047.

81 Inside the cozy but creepy world of VR sleep rooms | MIT Technology Review.

82 Hana Kiros (2023). Inside the metaverse meetups that let people share on death, grief, and pain. MIT Technology Review (January 12, 2023).

83 Riva, G., Di Lernia, D., Tuena, C., Bernardelli, L., Maldonado, J. G., Garcia, M. F., … Serino, S. (2021, September 14). COVID Feel Good – A Self-Help Virtual Therapeutic Experience for Overcoming the Psychological Distress of the COVID-19 Pandemic: Results from a European Multicentric Trial. https://doi.org/10.31234/osf.io/r23sa.

84 Impact of Virtual Reality (VR) Experience on Older Adults' Well-Being | Request PDF (researchgate.net).

85 Thus the conclusion of: Weinberg, H. (2020). Online group psychotherapy: Challenges and possibilities during COVID-19—A practice review. Group Dynamics: Theory, Research, and Practice, 24(3), 201–211.

86 Bond S, Laddu DR, Ozemek C, Lavie CJ, Arena R. Exergaming and Virtual Reality for Health: Implications for Cardiac Rehabilitation. CurrProblCardiol. 2021 Mar;46(3):100472.

normal-weight children. The metaverse could therefore be useful in helping obese children in particular to develop a love of sport.[87]

However, unlike most of the XR offers discussed in the literature, these benefits would not be targeted exclusively at people with certain health problems; they could in principle be used by everyone. Thus, the question of whether health insurance companies should have to pay for such exergaming experiences in the metaverse as part of a prevention strategy is up for discussion. For example, VR environments are already being used in the treatment of obesity patients to promote physical activity through gamified experiences. In a similar approach, the Horizon 2020-funded "Holobalance" project uses AR technology to support elderly people by way of a personalised digital coach platform.[88] The concept of exergaming thus illustrates how the metaverse could be used to promote healthy lifestyles and improve the physical and emotional well-being of the general population.

3 The route to a metaverse-ready health ecosystem in Europe

The foregoing section showed that the metaverse may be able to facilitate pain relief, stress reduction and rehabilitation, as well as provide new diagnostic techniques based on VR/AR. This also has implications in the "real" world as the resulting data will usually be directly linked to sales, which means that the metaverse also raises questions of competition and industrial policy. In the health sector, in particular, the envisaged applications for healthcare in the metaverse are already being developed by start-ups around the world, not by dominant players like the aforementioned Meta.[89] The examples given indicate enormous potential which could to some extent already be used today. In this section, we look in more detail at two major opportunities for Europe, namely wider access to healthcare and better, personalised services (Section 3.1). Nevertheless, the path from finding a possible worthwhile application through to establishing the whole thing in the reality of patient care is not an easy one. Both European and national requirements must be met, from licensing conditions and advertising laws to pricing and reimbursement by (health) insurance companies.[90] Here we focus on two primary challenges: the setting of uniform rules and customised data protection (Section 3.2).[91] With a new Metaverse TÜV, the underlying conditions could be established to give rise to a fully functioning metaverse health ecosystem in Europe, which makes use of the aforementioned opportunities and at the same time ensures adequate data protection (Section 3.3).

3.1 Opportunities: Improved access and innovative services

Accessibility of metaverse health services

[87] Rosa M. Baños, Patricia Escobar, AusiasCebolla, Jaime Guixeres, Julio Alvarez Pitti, Juan Francisco Lisón, and Cristina Botella (2016), Using Virtual Reality to Distract Overweight Children from Bodily Sensations During Exercise, Cyberpsychology, Behavior, and Social Networking 2016 19:2, 115-119.

[88] Vigkos, A., Bevacqua, D., Turturro, L., et al., VR/AR Industrial Coalition: strategic paper, Publications Office of the European Union, 2022, p. 17.

[89] See also BCG (2023), The Health Care Metaverse Is More Than a Virtual Reality.

[90] Seee.g. Kaulartz, M., Schmid, A., Müller-Eising, F. (2022), Das Metaverse – eine rechtliche Einführung, in: RDi 2022, p. 521 ff. orWiring, R,. Riese, R. (2022), Das Healthcare Metaverse: Neue Gesundheitsversorgung, neues Recht?.

[91] For suggestions along similar lines but outside the metaverse context, see also: Digital health: An opportunity to advance health equity | McKinsey.

Social and health protection for all EU citizens is an important goal of the EU. But the performance of health systems varies widely between different Member States, with major differences for example in maternal mortality rates during childbirth and pregnancy, and in death rates from cancer.[92] Against this backdrop, digital applications and services[93], and the metaverse technologies highlighted above, could make healthcare in the EU more accessible and more equitable, from simplifying hard-to-obtain treatments to removing travel and transport factors in accessing healthcare. In short: better access, better results and lower costs.[94]

However, the introduction of the relevant technologies could also create new inequalities within and between societies. The much-cited "digital divide" could persist in the metaverse health sector because access to the metaverse requires digital and financial literacy, high internet bandwidth, low latency, constant internet access and expensive hardware.[95] On the other hand, the metaverse could also have a strongly inclusive effect, as explained above. Access to innovative health metaverse technologies and inclusivity will ultimately be limited by monetary affordability and technical availability (e.g. poor coverage in rural areas) if these factors are not addressed. More cooperation is needed between policy makers, businesses and civil society to improve digital skills and increase digital connectivity.[96] At EU level, the Commission's Gigabit Infrastructure Act (GIA), which is intended to make gigabit expansion more efficient, faster and cheaper, is particularly worthy of consideration. But in its current form, the GIA is more likely to slow down fibre-optic expansion in Europe.[97] EU institutions should therefore improve the draft, especially against the background of the needs of the metaverse.

Innovative types of data will improve health services

In addition to broader and easier access to health services, Europe can benefit from the fact that the metaverse will generate the innovative types of data described above, which will allow machine learning to significantly improve medical services. Current healthcare datasets are often limited because anonymisation requirements result in the omission of characteristics such as gender and age. Previous use of algorithms in health decisions has therefore often led to discriminatory bias because inadequate proxies had to be used to substitute for missing data.[98] For example, AI programmes designed to detect disease on X-ray images of lungs have often been misled in the past because they focussed on the markings used to label the image - rather than medically relevant

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92 Peseckyte (2023), One 'unacceptable' maternal death every two minutes – EURACTIV.com; Peseckyte (2023), Cancer mortality varies wildly across the EU, new registry finds – EURACTIV.com.

93 See also Ludewig, G.; Klose, C.; Hunze, L.; Matenaar, S. (2021), Digitale Gesundheitsanwendungen: gesetzliche Einführung patientenzentrierter digitaler Innovationen in die Gesundheitsversorgung.

94 See also BCG (2023), The Health Care Metaverse Is More Than a Virtual Reality.

95 See: Matthew Ball, The Metaverse: And How It Will Revolutionize Everything, Liveright.

96 See also, for the USA: Deloitte, The Metaverse and its Potential for the United States, Final Report (May 2023), p. 5.

97 BREKO kritisiert Entwurf des Gigabit Infrastructure Act der EU (brekoverband.de).

98 For example, an algorithm widely used in the US led to unintentional racial discrimination, as a result of which the number of black patients selected for additional treatment fell by more than half. The distortion arose because the algorithm used health care costs as an indicator of health care needs. Less money is spent on black patients who have the same needs, so the algorithm wrongly concluded that black patients are healthier than equally ill white patients. The important finding here is that this racial bias *ceased* to arise once the algorithm was provided with better underlying data, where cost no longer had to be used as a proxy for need. See: Obermeyer, Powers, Vogeli, & Mullainathan. (2019). Dissecting racial bias in an algorithm used to manage the health of populations. Science, 366(6464), 447-453. 10.1126/science.aax2342.

features.[99] In this context, the wealth of new data that can be recorded in the metaverse promises to improve algorithmic predictions and screenings by making them more personalised and being able to draw on an even broader empirical base. For example, data on eye movements obtained in VR environments could be used for automated detection of various symptoms and pave the way for more accurate diagnostics.[100] This also, of course, gives rise to important data protection concerns, which will be discussed below.

The improved and much broader data base in the metaverse is of particular relevance in the health sector because AI systems there are currently afflicted by a so-called **reproducibility crisis**, i.e. many of the alleged achievements cannot be scientifically reproduced. In 2021, researchers evaluated 511 scientific papers from different AI subfields and found that machine learning algorithms designed for health performed significantly worse, compared to other fields, in terms of various reproducibility metrics, such as data and code accessibility.[101] For example, when researchers compared award-winning algorithms for automatic lung cancer diagnosis using CT scans with a subset of the scans, they found "substantial performance variations". They concluded that "there is plenty of room for improvement regarding model generalizability".[102] A major reason for using machine learning in healthcare to date is the scarcity of medical datasets, which can lead to inaccuracies and bias. According to experts, larger open data sets containing information from many different people are needed - metaverse applications in healthcare can generate this granular data, as described in detail above. As well as adding more data, research to find the most robust and best algorithms for healthcare applications must be promoted.[103]

A first step towards collecting and analysing this data may be the European Health Data Space ("EU Health Data Space" or EHDS) which is to form the basis for using health data EU-wide in the future.[104] The EU project is undoubtedly ambitious, and the legislative process far from complete, but the EHDS promises to bring substantial progress. Thus, health data will, among other things, be made usable for research and development. Data will come from a wide variety of sources including all electronic patient records as well as all wearables, such as smart watches.[105] The next step will be for the metaverse to generate and connect numerous data points from different people around the world that use wearables with heart rate monitoring or headsets with eye tracking. In other words: The EHDS will establish a foundation for the EU-wide, secure exchange of health data and the metaverse could then in the future help to make healthcare data sets larger and at the same time more representative and thereby promote modern AI applications with enormous potential for patients. This, however, would require the creation of standards for the collection of data in the metaverse

[99] Savage, N. (2023), Why artificial intelligence needs to understand consequences (nature.com) (24.02.2023).

[100] Merzon, L., Pettersson, K., Aronen, E.T. et al. Eye movement behavior in a real-world virtual reality task reveals ADHD in children. Sci Rep 12, 20308 (2022). https://doi.org/10.1038/s41598-022-24552-4.

[101] McDermott, Matthew B. A., Wang, Shirly, Marinsek, Nikki, Ranganath, Rajesh, Foschini, Luca, Ghassemi, Marzyeh (2021). Reproducibility in machine learning for health research: Still a ways to go, J Science Translational Medicine 13 (586), doi:10.1126/scitranslmed.abb1655, https://www.science.org/doi/abs/10.1126/scitranslmed.abb1655.

[102] Yu K, Lee TM, Yen M, Kou SC, Rosen B, Chiang J, Kohane IS, Reproducible Machine Learning Methods for Lung Cancer Detection Using Computed Tomography Images: Algorithm Development and Validation, J Med Internet Res 2020;22(8):e16709, doi: 10.2196/16709, https://www.jmir.org/2020/8/e16709.

[103] Savage, N. (2023), Why artificial intelligence needs to understand consequences (nature.com) (24.02.2023).

[104] See full summary in cep**PolicyBrief** 13/2023.

[105] Referred to in the EHDS proposal as "wellness apps"; these are devices or software, e.g. fitness watches or fitness apps, with which individuals can generate health data outside of institutionalised healthcare, e.g. in order to maintain a healthy lifestyle.

and for reporting about the results of AI applications based on this data, as well as the consent of participants to the use of their data. In addition, there must be rules to ensure that such products and services respect privacy. We turn our attention to these risks in the next section.

3.2 Risks: Regulatory conflicts and data protection

Regulatory gaps and conflicts in the metaverse

The metaverse will not just come into being in one fell swoop - there will be no "before the metaverse" and "after the metaverse". Instead, it will emerge over time as different products, services and capabilities are integrated and merge with each other.[106] As the metaverse will bring a multitude of innovative functions, data and opportunities in the course of this dynamic process, the application of existing regulatory regimes will be a real challenge.[107] Many of today's laws are simply not "fit" for the metaverse future. So far, there is not even a generally accepted legal definition of the term "metaverse".[108] Numerous regulatory gaps or conflicts can therefore be expected, especially in the early days.

For the purposes of illustration, we have selected a typical problem from the numerous examples of the likely regulatory challenges already contained in the literature[109]. For example, as AI solutions can be found in wearables or imaging devices that facilitate access to the metaverse, alignment of the planned AI Act with the Medical Device Regulation (MDR) and the In Vitro Diagnostics Regulation (IVDR) will be crucial in the future to facilitate access to innovative metaverse services. Under the proposed AI Act, medical devices or in vitro diagnostics, which are themselves an AI system or use an AI system as a safety component, would be subject to the MDR/IVDR and the AI Act. The law will determine how and whether new AI-based medical technologies are brought onto the market and reach hospitals and patients. According to the risk-based approach of the Commission's proposed AI Act, all AI-based medical technologies, among others, would be considered high-risk, as they would have to undergo a conformity assessment under the MDR/IVDR. In this regard, industry experts explain that uniform rules are important to avoid regulatory duplication and conflicts.[110]

Without such uniform rules, the problems of an already cumbersome regulatory system could be exacerbated. In particular, conflicting regulatory requirements may preclude healthcare providers and technology companies in the EU from offering innovative solutions to European patients in the future metaverse. However, the metaverse and its potential for healthcare are valuable for every single patient. Europe is also in a global competition when it comes to the use of health data. The potential of the metaverse for the health sector is thus clear to see - what Europe needs now is the political and regulatory will to move forward together, and especially now because there are multiple benefits to be gained from an early development strategy.[111] There is therefore an urgent need to

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[106] Ball, M. (2020), The Metaverse: What It Is, Where to Find it, and Who Will Build It.

[107] In a similarvein, see Bender-Paukens, L., Werry, S. (2023), Datenschutz im Metaverse, Datenschutzrechtliche Herausforderungen im Zusammenhang mit der DS-GVO, in: ZD 2023, p. 127 ff.

[108] See on this Meier, T., Medizinprodukte für das Metaverse, MPR 2022, p. 135.

[109] For further examples, see Wiring, R,. Riese, R. (2022), Das Healthcare Metaverse: Neue Gesundheitsversorgung, neues Recht?.

[110] This section is based on a detailed analysis of: Olbrechts, A. (2023), How the AI Act could unintentionally impact access to healthcare – EURACTIV.com.

[111] See also BCG (2023), The Health Care Metaverse Is More Than a Virtual Reality which gives these as, most notably, learning curve effects, network effects, first mover advantages, recognition effects and more innovation.

consider the present situation from a future perspective so that we can build a European health ecosystem[112] today, capable of ensuring that a truly digital health system, and thus a metaverse-ready health ecosystem, will be a reality in Europe in 20 years' time. As aspects of the metaverse materialise, ground-breaking legal issues will arise that are not yet foreseeable.[113] The process will not take place all at once but will be dynamic and constant.[114] To begin with, therefore, a Metaverse TÜV must be carried out on an ongoing basis, also covering data protection aspects, as set out below.

Data protection challenges in the metaverse

As many of the examples above show, in the metaverse, companies, health insurers and governments can reach new audiences in healthcare, create better products and build trust by engaging patients through new digital channels that were not - or not cost-effectively - available before. In doing so, however, they must first deal with the numerous - and constant - new data protection issues that arise[115]. This concerns areas as diverse as virtual consultations, VR-derived data and the application of advanced AI models in the metaverse. In the following, we focus on these privacy-related aspects of metaverse technologies, leaving aside other, more direct threats to health.[116]

Medical products and services in the metaverse will require the digital capture, archiving and use of images, videos and bio- and neural feedback, and it is important that this highly sensitive and personal data is managed in an ethical and secure manner. One option is to allow instant uploading of images or videos to a secure, encrypted server in the health system.[117]Recent evaluations already show serious data protection gaps in the current generation of telemedicine and doctor appointment portals, as e.g. often no or insufficient explicit consent is obtained for the processing of health data.[118] In the metaverse context, obtaining such consent is even more complex, as people move around in a unified, immersive digital world and "pass" from service to service without being able to check a box. In a study by the Federation of German Consumer Organisations (VerbraucherzentraleBundesverband), eight out of nine telemedicine providers investigated stated

[112] This refers to a regulatory and technical structure that covers all stakeholders - from patients, to doctors, to researchers - and encompasses the areas concerned - from AI algorithms, to physical devices for using the metaverse, to data. See also Wang, G. et al. (2022), Development of metaverse for intelligent healthcare.

[113] See also Norton Rose Fulbright (2021), The Metaverse: The evolution of a universal digital platform.

[114] It could, for example, be an aspect that an institution (Commission, Parliament, Council, national government, national parliament) must address by default when proposing a law.

[115] Against this background of open developments, a first approximation should (and can) be made here. See also Klar, M., Wegmann, S., Galandi, M. (2022), Datenschutz im Metaverse, in: BB 2022, p. 2691.

[116] For example, wearables, which are already widely used in sports contexts and could even become essential as certain metaverse applications start to be used, can cause electrical interference that prevents cardiac devices from functioning properly. Researchers found that the electrical current used in smart wearables during so-called "bioimpedance measurement" interferes with the proper functioning of some implanted cardiac devices from three leading manufacturers; for full summary see Gia-Bao Ha; Benjamin A. Steinberg; Roger Freedman; Antoni Bayés-Genís; Benjamin Sanchez (2023). Safety evaluation of smart scales, smart watches, and smart rings with bioimpedance technology shows evidence of potential interference in cardiac implantable electronic devices, Heart Rhythm, DOI:https://doi.org/10.1016/j.hrthm.2022.11.026. Using XR technology can also cause motion sickness. Ultimately, there are many "unknown unknowns", i.e. risks that we do not yet know about (e.g. the effect of long-term use on the reorganisation of a patient's brain); see also Meier, T., Medizinprodukte für das Metaverse, MPR 2022, p. 141 f.

[117] Khor WS, Baker B, Amin K, Chan A, Patel K, Wong J. Augmented and virtual reality in surgery-the digital surgical environment: applications, limitations and legal pitfalls. Ann Transl Med. 2016 Dec;4(23):454.

[118] VZBV (2023). Datenschutz bei Videosprechstunden, Ergebnisbericht der Untersuchung (February 2023).

that they used tracking services.[119] This could conflict with the EU's Digital Services Act[120] , which prohibits platforms from using sensitive data for advertising.

This problem applies even more in the context of an immersive virtual world, where, for example, a VR headset is used that is equipped with numerous cameras that track every movement of the eyelash. Ultimately, conclusions about a person's state of health can be drawn from this data. Latest research shows: People using VR headsets can already be clearly and reliably identified simply by recording their head and hand movements in relation to virtual objects.[121] Even though the role of data protection in the metaverse has been up for debate for some time, it is surprising how little VR data is needed to uniquely identify a user in the metaverse - this shows how difficult it will become to guarantee real data protection and privacy in virtual health services without regulation and the use of certain anonymisation techniques. Further privacy issues arise from the latest generation of generative AI, which is currently enjoying enormous popularity and is also being considered for digital services in healthcare. The problem with using them in healthcare metaverse environments is most notably the fact that these generative AI models memorise personal information and images in their training sets.[122]

Data protection in the metaverse is not simply a luxury that stands in the way of innovation, but is necessary right from the outset to ensure that these technologies can fully develop. In an online survey commissioned by the Federation of German Consumer Organisations (VerbraucherzentraleBundesverband), around three quarters of respondents stated that the protection of their data in relation to digital health services was either very or quite important to them.[123] Meeting high-quality data protection standards is therefore not only legally required for prospective providers of metaverse health services, but also necessary in terms of the business model in order to achieve social acceptance and thus also broad and successful application. In addition, as mentioned at the beginning of this section, there are new issues relating to competition and industrial policy, as data and distribution monopolies could arise as a result of market entry barriers or "metaverse entry barriers". The link between data protection and competition, which has repeatedly preoccupied European competition law in recent years, especially in the area of social media, is particularly evident in the metaverse. The combination of the two subject areas, which takes on a new and specific quality in the metaverse, thus supports the demand for a Metaverse TÜV.

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[119] VZBV (2023). Datenschutz bei Videosprechstunden, Ergebnisbericht der Untersuchung (February 2023).

[120] On the "DSA" see also the three-part Study by the Centres for European Policy Network.

[121] This is according to a recent study that collected data on a large number of real VR users. After training a classification model on 5 minutes of data per person, a user could be uniquely identified from the entire pool of 55,541 users with 94.33% accuracy from 100 seconds of movement and with 73.20% accuracy from only 10 seconds of movement. Nair et al. (2023). Unique Identification of 50,000+ Virtual Reality Users from Head & Hand Motion Data, arXiv:2302.08927v1 [cs.CR] 17 Feb 20, 23.

[122] Computer scientists at Google, DeepMind, UC Berkeley, ETH Zurich and Princeton recently demonstrated that state-of-the-art imaging models such as Stable Diffusion and Google's Imagen can be made to produce identifiable photos of real people and real medical images. In total, the group of researchers managed to extract over 100 replicas of images from the training set of the two AI models. This could also have implications for metaverse start-ups looking to use generative AI in healthcare, as research suggests that there could be uncontrolled dissemination of sensitive private information. Nicholas Carlini, Jamie Hayes, Milad Nasr, Matthew Jagielski, Vikash Sehwag, Florian Tramèr, Borja Balle, Daphne Ippolito, Eric Wallace (2023), Extracting Training Data from Diffusion Models, arXiv:2301.13188 [cs.CR].

[123] VZBV (2022), Videosprechstunden und Datenschutz. Results of an internet-representative survey by eye square GmbH on behalf of the vzbv (December 2022).

3.3 Solution: The Metaverse TÜV

In order to take advantage of the aforementioned opportunities for the health sector in Europe whilst ensuring that important data protection issues are not overlooked, we propose the introduction of a "Metaverse TÜV". The idea for this concept comes from the *Coalition for Health AI*, which recently published a "Blueprint for Trustworthy AI".[124] It calls for high transparency and safety standards for the use of the technology in medicine and recommends intensive human monitoring of AI systems during their operation as well as strict requirements for data protection and data security. Our earlier discussion of potential technologies, their current vulnerabilities and their reliance on patient trust suggests that these same elements are at the heart of a European approach to health applications in the metaverse and should be prioritised by the EU Commission in its strategy. In other words, transparency, safety standards, humans-in-the-loop models and data protection should become the ingredients of a new **technological and regulatory Metaverse TÜV** which could be used to prepare a metaverse-ready healthcare ecosystem in Europe.

Thus, in order to promote the development of a healthcare metaverse in the EU that exploits the aforementioned technical potential while minimising the risks, the EU should introduce a metaverse certification system comparable to the TÜV system used in Germany. This **Metaverse TÜV** would aim to assess and verify the security and privacy aspects of metaverse platforms in the healthcare sector. For this purpose, the Commission would first work with experts, stakeholder groups and regulators to define comprehensive **certification criteria** for health applications in the metaverse. In this regard, for example, the recommendations of the EU Citizens' Panel can be used as a reference, as well as the studies discussed above. Thus, data protection, security, interoperability, ethical considerations, user privacy and compliance with relevant regulations such as the General Data Protection Regulation (GDPR) are likely to be relevant for defining certification criteria. Of crucial importance is the interaction with European data protection.[125] It is clear that the metaverse poses a challenge to data protection principles[126] - especially because an unprecedented amount of biometric health data is being created.[127] With this comes a great responsibility.[128] The resulting areas of tension cannot easily be resolved but they can be contained, for example, by interpreting data protection principles in a manner that is open to innovation and technology.[129] In addition, there are the aforementioned issues of competition and industrial policy which will directly affect access to - and thus the desired inclusivity of - the health system in the metaverse. Precisely because the metaverse promises to integrate various technologies into one singular new environment, which has to meet certain requirements in terms of data protection and access,which are not sufficiently verifiable either by users or the competition, an external institution is needed to carry out monitoring and supervision.

124 Blueprint for Trustworthy AI. Implementation Guidance and Assurance for Healthcare (2023) (coalitionforhealthai.org).

125 Data protection is often described as a "brake" on digitalisation in the health sector; see also the guest article by Federal Data Protection Commissioner Kelber of 4 February 23: https://netzpolitik.org/2023/digitalisierung-und-datenschutz-schluss-mit-ausreden/.

126 Also on thissee Klar, M., Wegmann, S., Galandi, M. (2022), Datenschutz im Metaverse, in: BB 2022, p. 2694.

127 See also Bender-Paukens, L., Werry, S. (2023), Datenschutz im Metaverse, Datenschutzrechtliche Herausforderungen im Zusammenhang mit der DS-GVO, in: ZD 2023, p. 128 and Norton Rose Fulbright (2021), The Metaverse: The evolutionof a universal digital platform.

128 Also the view of Norton Rose Fulbright (2021), The Metaverse: The evolution of a universal digital platform.

129 Also on thissee Klar, M., Wegmann, S., Galandi, M. (2022), Datenschutz im Metaverse, in: BB 2022, p. 2691 ff.

On the basis of the selected criteria, the EU Commission could then authorise **independent certification bodies** to examine metaverse platforms in the healthcare sector to determine whether the platforms meet the specified certification criteria. At this point, we will deliberately leave open the question of whether these certification bodies will be newly set up or whether they can be based on structures that are already emerging, such as the new *European Centre for Algorithmic Transparency* (ECAT) or the *AI Office* planned within the framework of the AI Act. Developers of metaverse-based healthcare services would in turn submit their applications for certification to the appointed bodies. Certification bodies would have to conduct a thorough assessment of the platforms, taking into account factors such as data processing practices, security measures, user consent mechanisms and compliance with the GDPR - in accordance with the criteria developed. As in the TÜV system, **technical testing** would play a crucial role in the certification process. For example, certification bodies would conduct audits of data anonymisation, and vulnerability tests such as red teaming (simulated attacks on a system) to ensure that the metaverse platforms meet the required security standards.

Data from electronic patient records, CT scans and other medical images, for example, can be uploaded from the hospital bed to a cloud environment via an encrypted VPN*(Virtual Private Network*) connection, offering confidentiality along the entire processing chain thanks to specific execution environments.[130] In addition to such reliable execution environments, numerous other approaches are available to mitigate privacy risks when using sensitive or confidential data in the metaverse, but these often get short shrift in the discussion. Such methods - some still experimental, others already in practical use - are collectively referred to as privacy-enhancing technologies.[131] With these methods, health facilities can work together to train AI models without sharing sensitive raw data.[132] The security and privacy features offered by these methods are clearly linked to the values that the EU is increasingly embedding in its data regulation. Privacy technologies are a product of the precautionary principle and are consistent with the principles of "privacy by design" developed under the EU's AI Act.

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[130] In order to protect this sensitive data, for example, it is current practice to use so-called "confidential computing". Confidential computing refers to the protection of data when using hardware-based trusted execution environments *(*"TEE"). A trusted execution environment is a feature of modern processors (CPUs) that mitigates the problems of input privacy, code protection and code security. In other words, this technique promises confidentiality along the entire processing chain because relevant information is not only encrypted during storage and transmission, but also executed in a protected area of the processor, known as the enclave. See: Digital Twin in der Medizin: Mit KI und Confidential Computing zu besseren Behandlungsmethoden | heise.

[131] These include, in particular, secure multi-party computation, homomorphic encryption, differential privacy and distributed learning. See: Task Team of the UN Committee of Experts on Big Data and Data Science for Official Statistics (2023), UN Guide on Privacy Enhancing Technologies for Official Statistics, UN-CEBD. In addition, blockchain technologies will also play an important role in zero-trust environments, e.g. for storing patient data - thus the pseudonymisation of data in the metaverse could be achieved e.g. through blockchain encryption: Bender-Paukens, L., Werry, S. (2023), Datenschutzim Metaverse, DatenschutzrechtlicheHerausforderungenimZusammenhangmit der DS-GVO, in: ZD 2023, p. 127-131, especially p. 129; BCG (2023), The Health Care Metaverse Is More Than a Virtual Reality and Wang, G. et al. (2022), Development of metaverse for intelligent healthcare. See also European Union Agency for Cybersecurity, ENISA, (2023), Engineering Personal Data Sharing.

[132] Several years ago, an academic research project already proposed various configurations for a distributed deep learning method called SplitNN to facilitate such collaborations. SplitNN does not share raw data or model details with collaborating institutions and is particularly aimed at institutions with varying modalities of patient data and centralised and local health institutions collaborating on multiple tasks.PraneethVepakomma, Otkrist Gupta, Tristan Swedish, Ramesh Raskar (2023). Split learning for health: Distributed deep learning without sharing raw patient data, arXiv:1812.00564 [cs.LG].

As mentioned above, the emergence of a health-relevant metaverse will be a process that unfolds slowly rather than a watershed moment All updates and changes to the platforms and their policies would therefore have to be continuously assessed to maintain the integrity of the certification proposed here. Successfully certified healthcare metaverse platforms would receive a recognisable **seal ofcertification** indicating their compliance with the established standards. The certification bodies would maintain a publicly accessible database of certified providers, allowing users to verify the standards of a particular metaverse health service before deciding to use it. Such a metaverse certification scheme will allow the EU to foster the development of healthcare metaverse platforms that offer innovative healthcare solutions while protecting user data and privacy - especially because the certification process would build much-needed trust among users.

4 Conclusion: A Chance for Europe

The metaverse is on the point of triggering a process of change in the healthcare sector, even though the majority of consumers have never heard of a health-related metaverse. Basically, it is a multi-sensory environment that will generate an enormous amount of health-related data on a scale and with a level of detail that is historically unprecedented. This will lead to significant improvements in machine learning applications and could lead medicine out of its current "reproducibility crisis". In view of the already foreseeable regulatory competition with the USA and China, the EU Commission's metaverse strategy should be increasingly focused on the health sector. This cep**Input** therefore recommends the introduction of a pan-European Metaverse TÜV that engages all stakeholders, including patients, doctors and researchers, and which includes in its certification process the multitude of areas involved, including AI algorithms and physical devices storing metaverse data.

The metaverse will create new opportunities in the healthcare sector for medical professionals and medical companies. As the numerous examples in this study show, positive effects can be expected most notably in education and training, remote communication and telemonitoring, and analysis and diagnosis. Concepts such as that of a VR- and AR-enriched "Health City" are already showing how classic health industries must change.[133] At the same time, patients will also benefit from this new technology. They can use virtual worlds for the purpose of digital twins, health policy awareness, pain relief, immersive therapies, virtual counselling and "exergaming". The metaverse therefore has the potential to revolutionise healthcare and provide wider access to treatment methods. As the metaverse produces a variety of innovative functions, the application of existing regulatory regimes is difficult.[134] In particular, the metaverse poses a challenge to existing data protection principles - especially since the amount of biometric data is increasing exponentially.[135]

These opportunities and risks for the European healthcare sector from the metaverse must be addressed by establishing a legal framework so that "Europe's profile as a prime location for innovation and the associated adequate level of healthcare"[136] can continue to be guaranteed in

[133] In thisregardsee Meier, T., Medizinprodukte für das Metaverse, MPR 2022, p. 136.
[134] In a similarvein, see Bender-Paukens, L., Werry, S. (2023), Datenschutz im Metaverse, Datenschutzrechtliche Herausforderungen im Zusammenhang mit der DS-GVO, in: ZD 2023, p. 127.
[135] See also Bender-Paukens, L., Werry, S. (2023), Datenschutz im Metaverse, Datenschutzrechtliche Herausforderungen im Zusammenhang mit der DS-GVO, in: ZD 2023, p. 128.
[136] Meier, T., Medizinprodukte für das Metaverse, MPR 2022, p. 134 f.

Europe. Health should therefore be prioritised in the design of the Commission's proposed Metaverse strategy - this would also be in line with the demands of the EU Citizens' Panel. Criteria such as data protection, accessibility, transparency, security standards and human control of monitoring and decision-making must be taken into account in the form of a new certification system, for which this report is proposing a new Metaverse TÜV. In addition, there are the aforementioned issues of competition and industrial policy which will directly affect access to - and thus the desired inclusivity of - the health system in the metaverse. Precisely because the metaverse promises to integrate various technologies into one singular new environment, which has to meet certain requirements in terms of data protection and access,which are not sufficiently verifiable either by users or the competition, an external institution is needed to carry out monitoring and supervision.

Overall, this analysis shows that the metaverse is a promising development that could significantly enrich the healthcare system in Europe in the face of the challenges of demographic change. To realise this potential, it is important for the EU to adapt its strategy accordingly. A comprehensive certification system that ensures an appropriate level of data protection as well as broad accessibility is essential to gain patient trust and promote the adoption of metaverse applications in healthcare. A transparent certification system, easily accessed via a public database, would promote the formation of a European health ecosystem, i.e. a regulatory and technical structure that engages all stakeholders - from patients to doctors to researchers - and meaningfully covers the areas concerned - from AI algorithms to physical devices for using the metaverse through to data.[137]By targeting its metaverse strategy at healthcare, the EU can play a strategic role in this evolving digital space and benefit people.

[137] See also Wang, G. et al. (2022), Development of metaverse for intelligent healthcare.

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