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The perspective of allergy and immunology specialists on the innovations of metaverse: A survey study

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Abstract
Background: New technologies have resulted in dramatic shifts in the field of medicine, and it stands to reason that metaverse will also affect the practice of allergy and immunology. This study aimed to determine the attitudes of allergists and raise awareness about metaverse applications in allergy and immunology.
Methods: A nationwide survey-based study was conducted in Turkey. First, a 28-item questionnaire was developed and sent to Turkish allergists. After completing the first questionnaire, the participants were asked to watch a 5-min informative video about the metaverse. Lastly, a second survey was conducted to evaluate the changes in the views of the participants.
Results: A total of 148 allergy doctors in Turkey participated in the survey. After watching a video containing updated information about the metaverse, there was a significant increase in the importance that participants attributed to the use of virtual reality and augmented reality applications in the field of immunology and allergy ($P < 0.05$). Additionally, there was a significant increase in the percentage of participants who thought that Metaverse applications could be integrated into the existing system and said that this possibility excited them ($P < 0.05$). There was also a significant increase in the percentage of participants who thought this innovative technology could be helpful in patient examination, student and physician education, allergy testing, and patient education ($P < 0.05$).
Conclusions: Our results demonstrate that providing information to professionals working in the field can positively influence physicians' views on the potential of the metaverse, which is a valuable tool in the field of immunology and allergy.

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Introduction

In his 1992 science fiction novel "Snowcrash," Neal Stephenson coined the term "Metaverse" by combining the roots "meta," meaning "beyond," and "Universe," meaning "all existing matter and space." The once-fictional phrase "metaverse" is now a viable possibility due to the rapid progress of technological advancements in the present day. Since the COVID-19 pandemic, it has been a topic of intense debate and refers to the internet accessed via virtual and augmented reality technology.[1] Virtual reality (VR) combines reality and imagination with technologically generated fiction. VR provides an immersive experience, and it is abstracted from reality. Augmented reality (AR) enhances and enriches actual life by rendering it more interactive. The connection to the actual world is maintained in AR. In the context of the metaverse, VR ad AR can be used to overlay digital information and media onto the real world, creating an immersive and interactive experience. Metaverse is generally viewed as the next-generation mobile computing platform that will be widely utilized in the future. Numerous large technological corporations actively invest in developing their metaverse platforms, including Alphabet, Amazon, Meta (Formerly Facebook), Microsoft, and Roblox. As technology advances, it is expected that the metaverse will also impact allergy and immunology practice. Even though many academics have provided ideas concerning the use of the metaverse in their particular fields of study, relatively few studies evaluated the knowledge and perspectives of medical physicians on this matter.[2-6] In a letter to the editor, we discussed the potential application areas of metaverse technology in our field, believing allergy specialists should be aware of these advancements and begin brainstorming immediately.[7] This study proposed the use of AR tools in drug allergy testing, the implementation of digital twins in patient education, label reading of patients with food allergies through the use of their avatars, and the demonstration of the underlying mechanisms of diseases via holographic construction.

Metaverse technology has numerous potential clinical applications, including creating digital twins, which are virtual duplicates of the patient. For instance, a digital twin can be created for an allergy patient who has been prescribed self-medication but is unsure how and when to take it. While the doctor and patient meet in the metaverse, this digital twin can act as a test subject to demonstrate the symptoms of diseases. Metaverse will enable information exchange between the patient and the health care provider and determine the appropriate treatment using AR tools. Metaverse applications have the potential to aid clinicians in conducting allergy testing. By utilizing AR technology through 3D glasses, patients can be immersed in a comfortable and safe environment, alleviating their worries about the hospital setting and procedures. For younger patients who may have difficulty staying still during the test, using metaverse technology can transport them to a playful and interactive environment, where even the administering health worker can be transformed into their favorite superhero. Not only does this help reduce patient anxiety, but it can also increase the accuracy and sensitivity of interpreting allergy test results. Within the realm of doctor education, holographic construction is another promising application of the metaverse. This innovative technology allows for a comprehensive 3D visualization of internal organs and body parts, providing healthcare professionals with a detailed understanding of complex conditions such as chronic inflammation in asthma or the development of internal organ edema in hereditary angioedema.

To expand the discussion, we conducted a survey to assess the knowledge level of allergy and immunology doctors in our country about the "metaverse" and their perspectives on its use in daily practice. We also aimed to investigate whether our more senior colleagues and junior physicians approached the metaverse differently. To the best of our knowledge, this is the first study to evaluate the attitudes of allergists toward metaverse technology.

Materials and Methods

We conducted a nationwide online survey-based cross-sectional study among allergists in Turkey. The authors prepared pre- and post-intervention questionnaires and an informative video regarding metaverse. The Non-Interventional Clinical Research Ethics Committee of Izmir Katip Celebi University, Izmir, Turkey approved the study (Number i6-361-20). Electronic informed consent was obtained from all participants before their information was collected. Confidentiality of personal information was maintained throughout the study by making participants' answers anonymous.

The study consisted of three steps, as shown in Figure 1. The first step involved completing a questionnaire to assess initial knowledge and attitudes toward the metaverse. The second step involved watching an informative video about the metaverse. The informative video provided to the participants was approximately 5 min long and covered various aspects of the metaverse, including its definition, potential uses, and limitations. The video was presented by one of the authors, an allergy and immunology expert with no conflicts of interest to declare. The content of the video was based on current research and industry trends and was designed to provide participants with up-to-date information about the metaverse. The video was presented in an easy-to-understand and visually appealing format, with clear and concise explanations of the concepts presented. The third step involved completing the same questionnaire again to assess changes in attitudes. The questionnaire included demographic information, binary questions about metaverse concepts, and statements about possible uses of the metaverse in daily practice, rated on a Likert scale.

Participants were recruited through emails and WhatsApp. Participants who refused to participate in the study were excluded, as were those who could not be contacted. The objectives and the purpose of the survey were explained to the participants in an introductory paragraph. To validate the questionnaire, we sought input from three allergists and an information technology engineer, who had no conflicts of interest to declare. Based on their feedback, we modified the questionnaire and the informative video.

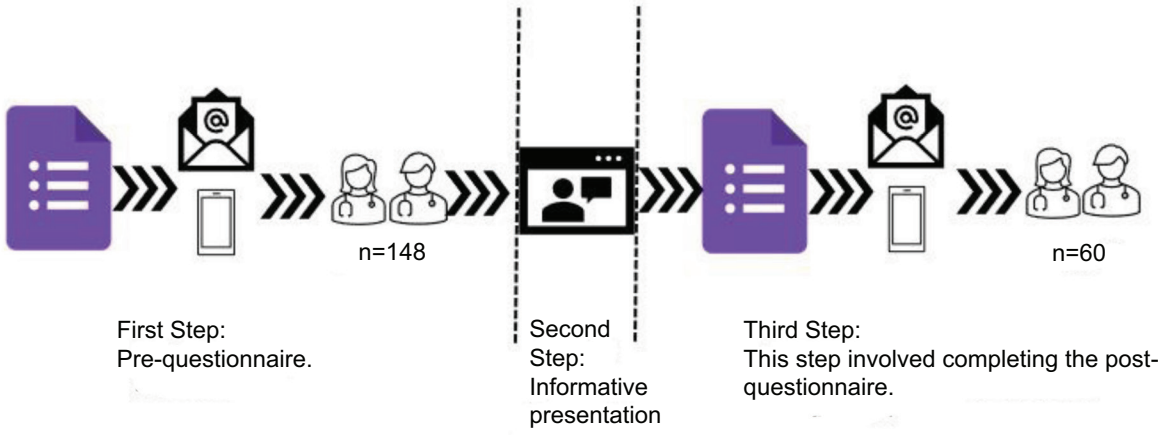

Figure 1 Flow diagram illustrating the study design and the steps involved in the survey.

Statistical analysis

The frequencies and percentages were given for categorical variables, and mean, standard deviation (SD), median, and range (minimum-maximum) values were given for numerical variables as descriptive statistics. The distribution of responses to survey questions by demographic characteristics was analyzed with Fisher's exact test (if not possible, the simulated p-value was used). The McNemar Bowker test (exact test) was used to investigate whether the answers given by the participants to the questions changed after the information.

Statistical significance was assessed at $P < 0.05$, and all statistical analyses were performed using R software (R software, version 4.0.5, package: arsenal, R Foundation for Statistical Computing, Vienna, Austria; http://r project.org) and STATA 13 (StataCorp. 2013. Stata: Release 13. Statistical Software. College Station, TX: StataCorp LP. function: symmetry).

Results

General demographic data

The survey was sent to nearly 500 allergists. A total of 148 participants, including 109 females (73.6%) and 39 males (26.4%), participated in the study. Fifty-three participants (35.8%) were pediatric allergists, and the mean age was 42.2 years (SD = 7.8). Most participants (50.7%) had more than 5 years of professional experience. The total number of participants from Turkey's most crowded three provinces was 96 (64.9%). The detailed demographic characteristics of the participants are shown in Table 1.

Knowledge levels and attitudes toward metaverse before being informed

The baseline knowledge level of metaverse-related terms among our study group is depicted in Figure 2. Only six (4.1%) of the respondents stated that they had sufficient knowledge about metaverse technology in general. When asked about metaverse applications in the medical field, this number dropped to four (2.7%). As shown in Figure 3, less than half of the participants believed that VR and AR applications were necessary for allergy and immunology. However, a nearly equal number of participants thought that digital twin applications could be significant. Figure 4 illustrates the responses to the question of how much of the minimum budget for metaverse integration participants could afford. We found statistically significant differences when we compared the responses of male and female participants. Among men, 25.6% indicated they could afford the required amount, while only 9.2% of women said the same ($P = 0.020$). Subgroup analysis by age revealed no significant differences between participants aged 40 and above and those below 40 in their knowledge of metaverse technology.

Less than half of the participants (44.6%, n = 66) disagreed to metaverse as an alternative to conventional medicine applications. In comparison, 55.4% (n = 82) thought it could be an advantage to existing telemedicine methods. Two-thirds of the participants (n = 99) did not anticipate that Metaverse applications would be routinely used in immunology and allergy within the next ten years. Nearly two-thirds of the participants (n = 98) said that Metaverse applications could benefit both medical and patient education. At the same time, a smaller number (35.1%, n = 42) and (12.9%, n = 19) thought they could be beneficial for patient examination and allergy testing, respectively. If Metaverse technology is integrated into conventional healthcare delivery, the majority of participants (93.2%, n = 138) believed that legal issues could arise, and a similar number were concerned about medical ethics (91.2%, n = 135) and data privacy (88.5%, n = 131).

Participants' knowledge levels and approaches to metaverse technology after being informed

Participants who watched a video on metaverse and then completed a post-survey had significantly more years of experience in immunology and allergy than those who did

Table 1 Demographic characteristics of the participants.

Parameters	Completed only pre-questionnaire (n = 88)	Completed pre- and post-questionnaires (n = 60)	p value	Overall (n = 148)
Gender				
Female	65 (73.9%)	44 (73.3%)	1.000*	109 (73.6%)
Male	23 (26.1%)	16 (26.7%)		39 (26.4%)
Age				
Mean (SD)	42.3 (8.4)	42.0 (6.9)	0.753**	42.2 (7.8)
Median (Range)	39.5 (32–67)	42.0 (32–72)		41.0 (32–72)
Province				
Most crowded provinces (Istanbul, Ankara, Izmir)	59 (67.0%)	37 (61.7%)	0.822***	96 (64.9%)
Other provinces	29 (33.0%)	23 (38.3%)		52 (35.1%)
Profession				
Pediatric allergy	32 (36.4%)	21 (35%)	1.000*	53 (35.8%)
Adult allergy	56 (63.6%)	39 (65%)		95 (64.2%)
Health Institution				
Academic tertiary Institutions of universities	46 (52.3%)	21 (35.0%)		67 (45.3%)
Academic tertiary Institutions of the government	32 (36.4%)	31 (51.7%)	0.167***	63 (42.6%)
Public hospitals	4 (4.5%)	2 (3.3%)		6 (4.1%)
Private hospitals or clinics	6 (6.8%)	6 (10.0%)		12 (8.1%)
Years of professional experience mean (SD)	7.7 (8.7)	8.7 (6.4)	0.007**	8.1 (7.9)
0–5 years	53 (60.2%)	20 (33.3%)	<0.001***	73 (49.3%)
5–10 years	12 (13.6%)	24 (40.0%)		36 (24.3%)
10–15 years	7 (8.0%)	11 (18.3%)		18 (12.2%)
>15 years	16 (18.2%)	5 (8.3%)		21 (14.2%)

*Fisher's Exact Test for Count Data;
**Wilcoxon rank sum test;
***Fisher's Exact Test for Count Data with simulated P value (based on 2000 replicates).
SD: Standard deviation

not participate in the post-survey. (P = 0.07, Wilcoxon rank sum test). Post survey, it was observed that the participants' familiarity and knowledge levels about Metaverse technology increased significantly according to the symmetry test (P < 0.001). In the post-survey, we found that the importance that the participants attributed to the use of VR and AR applications in the field of immunology and allergy increased significantly (P < 0.01). Although the proportion of participants who said they would make the necessary expenditure for Metaverse integration increased to 18.3% from 13.5%, it was not statistically significant (P = 0.45). A statistically insignificant decrease was observed in participants who thought that examination in the Metaverse environment could not be an alternative to current conventional examination methods, from 44.6 to 28.3% (P = 0.55). The symmetry test revealed a significant shift in the proportion of participants who thought Metaverse applications could be an appropriate approach to providing medical care services to patients after receiving video information (P < 0.001). Of the 60 participants who completed the post-survey, 12 (20%) changed their answers from abstaining to agreeing. Participants who believed that Metaverse applications could be integrated into the existing system and those who stated that this possibility excited them increased from 35.8 to 66.6% and 41.9 to 71.6%, respectively (P < 0.05). There was also a significant increase in the percentage of participants who thought this innovative technology could be helpful in patient examination, allergy testing, and medical and patient education (P < 0.05; Table 2).

Discussion

The metaverse refers to a virtual world created by the convergence of VR and the real world, allowing users to interact with each other and with objects in a virtual environment. Very little was found in the literature on the question of how the metaverse can impact the medical field. To the best of our knowledge, this is the first nationwide study to assess the knowledge and perspectives of allergy and immunology experts about metaverse technology. The survey results suggest that allergy and immunology specialists in our country have limited knowledge and awareness about the metaverse and its potential use in

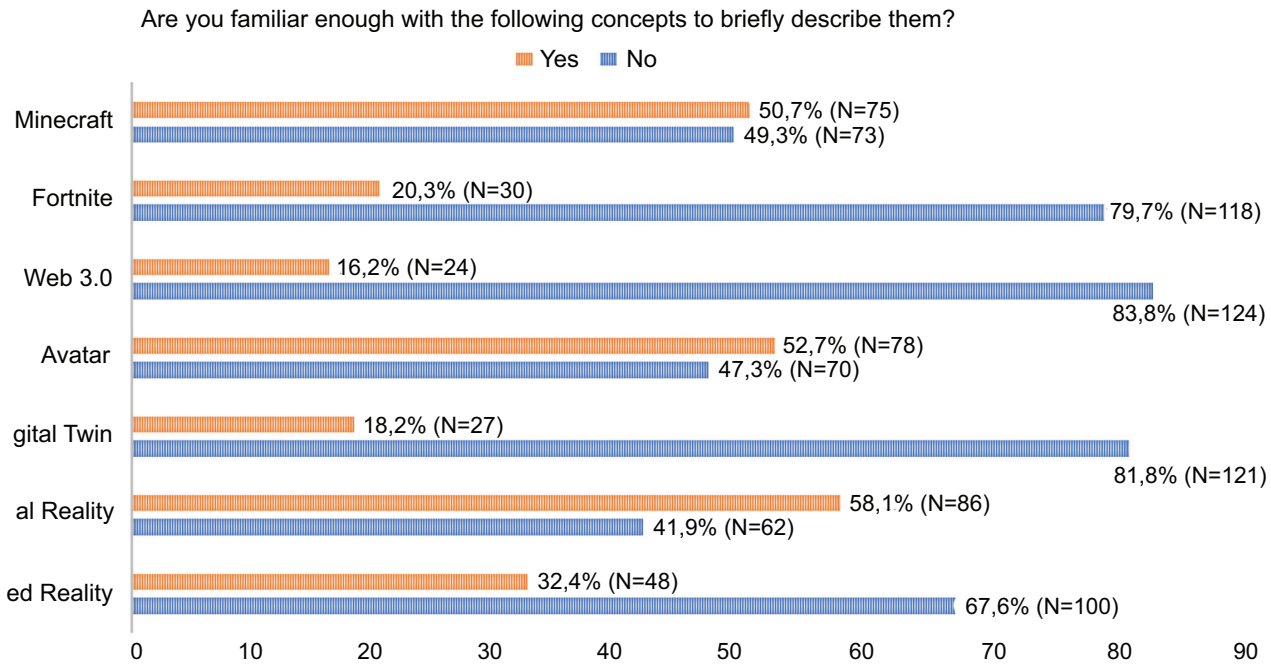

Figure 2 Knowledge of metaverse-related terms among allergists.

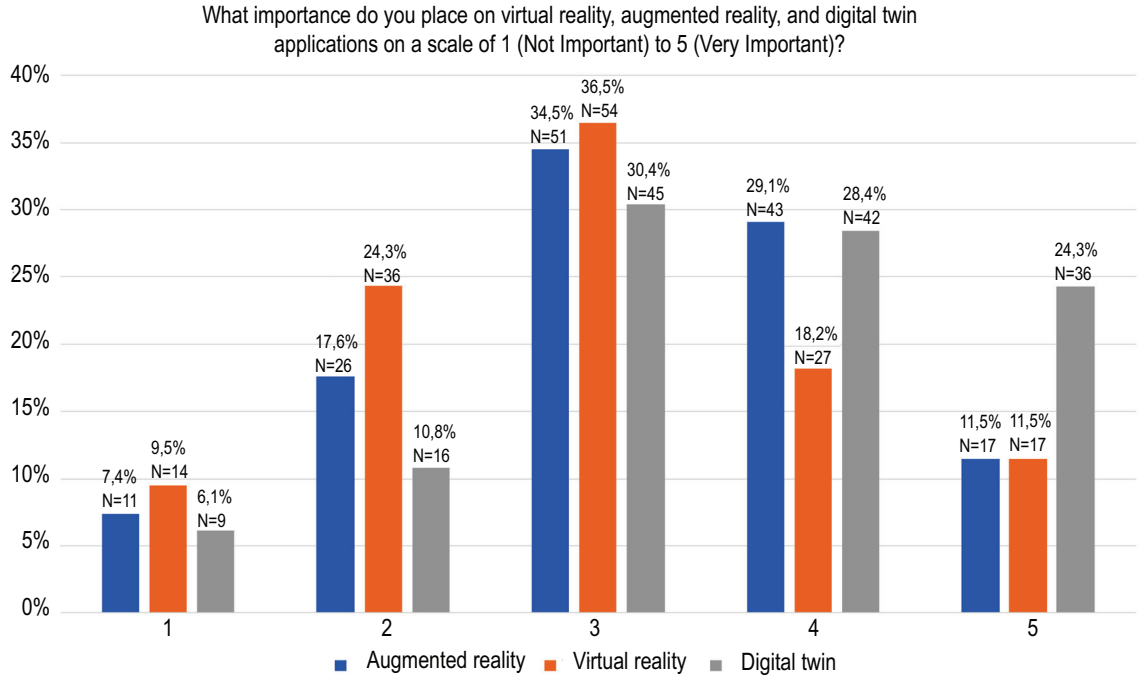

Figure 3 Importance of virtual reality, augmented reality, and digital twin applications in allergy and immunology.

daily practice. This is reflected in the low proportion of participants who indicated they had sufficient knowledge about the metaverse in general and its applications in the medical field.

Additionally, a large proportion of participants were unaware of key terms related to the metaverse, such as AR and VR. One possible explanation for our participants' lack of metaverse knowledge is that doctors are too busy with patient care and administrative tasks to learn about emerging technologies.

As mentioned in the literature review, the metaverse can be used for telemedicine, remote surgeries, medical simulations, and training in the medical field.[4-6,8-12] Even though the majority of these publications on the use of the metaverse in medicine contain hypothetical assumptions, research utilizing AR, the foundation of metaverse, has

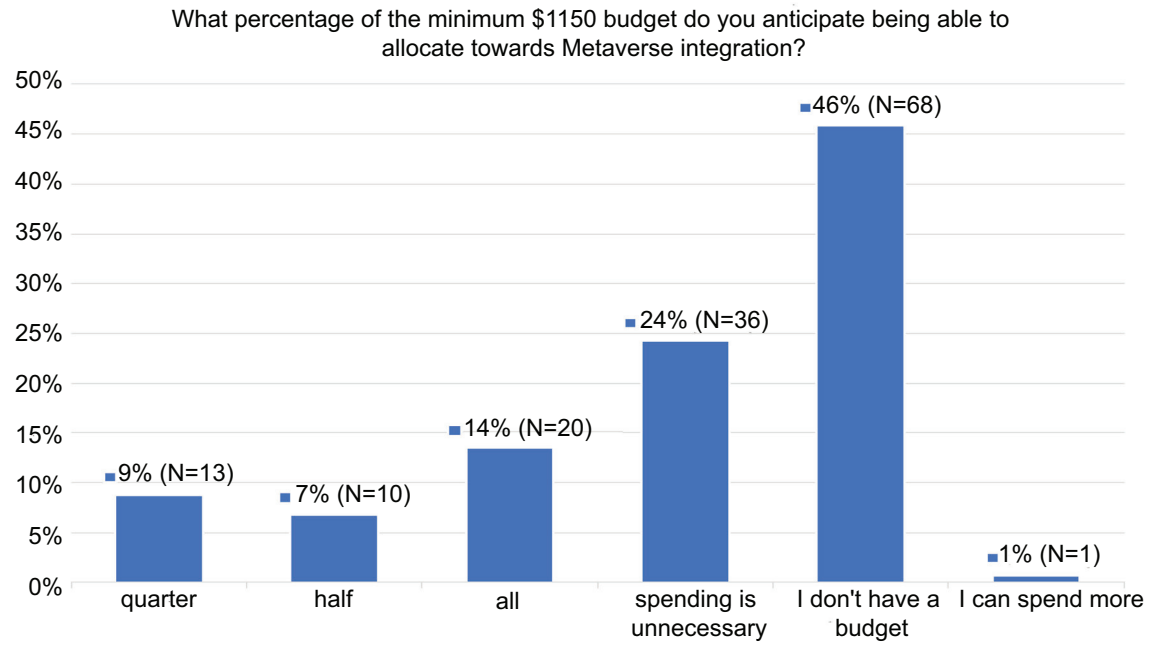

Figure 4 Allocation of budget for metaverse integration.

Table 2 Changes in the opinions of the participants.

Statement	Pre-survey	Post-survey	P
I agree/strongly agree that metaverse can be useful regarding patient examination.	35.1%	56.6%	0.005
I agree/strongly agree that metaverse applications can be useful in allergy testing.	12.9%	36.6%	0.004
I agree/strongly agree that metaverse applications can be useful in medical education.	63.6%	86.6%	0.002
I agree/strongly agree that metaverse applications can be useful in patient education.	64.9%	85.0%	0.027

demonstrated that this technology is applicable and valuable, particularly in the fields of surgery and psychiatry.[13-17] A study that evaluated AR during percutaneous vertebroplasty found that it was accurate and safe and resulted in less patient radiation exposure compared to traditional fluoroscopic guidance.[18] A meta-analysis intended to carefully assess existing evidence supporting the efficacy of VR therapy for the treatment of post-traumatic stress disorder and determined that it was more successful than waitlist control groups and comparable to other psychotherapies.[19] A recent systematic analysis comprising 27 studies with a total of 956 participants assessed the efficacy of AR and VR for medical education and concluded that VR-based teaching has positive benefits.[20] Additionally, the metaverse can enhance patient education by providing interactive and engaging resources.[21] In allergy and immunology, telemedicine is increasingly used to improve health outcomes, particularly asthma.[22-24] The majority of respondents to our survey agreed that metaverse applications could serve as an alternative to current telemedicine applications. We consider this a significant finding that suggests the use of the metaverse in our field should be investigated and discussed further.

After informing our study group, their perception regarding if immunology and allergy specialists could benefit from metaverse applications in their daily practice increased significantly. This finding supports our earlier presumptions that metaverse technology could be helpful for drug allergy testing and educating patients with diseases such as asthma, hereditary angioedema, and anaphylaxis.[7]

One potential limitation of our study is that it was conducted solely in Turkey, so the results may not be generalizable to other countries or regions. It is also possible that self-selection bias may have played a role in the results, as those who were more interested in or knowledgeable about metaverse technology may have been more likely to participate in the study. Additionally, the study experienced a high dropout rate, with only 60 out of the initial 148 participants (40.5%) completing the video and subsequent

post-questionnaire. It is possible that those who dropped out were individuals who were either not interested or did not perceive the use of metaverse technology as helpful in their practice. Finally, due to our study's pre-post design nature, the potential for response shift bias should be considered when interpreting the results.

Conclusion

Our current study found that, after receiving information about the metaverse through an informative video, there was a significant increase in the importance that participants attributed to the use of VR and AR applications in the field of immunology and allergy. There was also a significant increase in participants who thought that the metaverse could be integrated into the existing system and that this possibility excited them. Our findings suggest that providing information and education about the metaverse can positively influence specialists' views on its potential value in the field of immunology and allergy.

While the metaverse is still in its early stages of development, it has the potential to transform the way healthcare is delivered and experienced. Further research is needed to determine the most effective methods for increasing knowledge and awareness about the metaverse among physicians.

Acknowledgments

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Conflict of Interest

The authors have no conflicts of interest to declare.

Authors' Contributions

PC and RK made substantial contributions to this design of this work. CTD drafted and revised this work critically for important intellectual content.

Statement of Ethics

This study was approved by the Non-Interventional Clinical Research Ethics Committee of Izmir Katip Celebi University, Izmir, Turkey (Number i6-361-20).

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Data Availability Statement

The data that support the findings of this study are not publicly available due to the privacy of research participants but are available from the corresponding author (PC) upon reasonable request.

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