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REVIEW ARTICLE

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Analysis of e-Learning in Undergraduate Medical Education During Pandemic: Future Perspectives For Post-Covid Era

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ABSTRACT

Background: The global Covid-19 pandemic has had a profound effect on medical education. Social distancing leads to the implementation and development of e-learning, especially in the medical education field. E-learning is an innovative learning method using technology that allows students to learn flexibly because learning materials are visualized in various formats that students easily access.
Aims: This article aims to help researchers map and visualize research data related to the use of e-learning for the effective medical education in the future.
Methods: This article uses the bibliometric analysis method. It is a quantitative method for analyzing bibliographic data of published articles from reputable sources using the VOSviewer app. We analyzed 949 high-quality research articles from the Scopus database on August 14, 2022.
Results: It shows that the publications related to the implementation of e-learning in medical education during the Covid-19 pandemic began to increase from 2020 to 2021 and decrease in 2022. Research that focuses on developing e-learning methods in undergraduate medical students needs to be conducted in the future as part of academic development for the medical education system.
Conclusion: The medical community needs to continue paying attention to research the implementation of e-learning in medical education as related research begins to decline in 2022. E-learning also beneficial for students in terms of knowledge, skills, and attitudes. Even after the pandemic, it is expected that e-learning will still be a beneficial mode of study.

Keywords: e-learning; medical education; Covid-19; bibliometric

PRACTICE POINTS

- The medical community needs to continue paying attention to research the implementation of e-learning in medical education as related research begins to decline in 2022.
- Even after the pandemic, it is expected that e-learning will still be a beneficial mode of study.
- Based on our bibliometric analysis, researchers in medical education field needs to focus on how to maximize the benefits of e-learning methods in medical education in the post-covid era because e-learning methods has potency to develop a better medical education in the future.
- E-learning is beneficial for students in terms of knowledge, skills, and attitudes.

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INTRODUCTION

The Covid-19 pandemic that has hit the whole world has hampered the education sector.[1,2] The direct impact on the medical education sector is the occurrence of learning from distance for medical students.[3] This condition raises public concerns about the possibility that medical science is not conveyed properly to medical students. Because, in fact, medical learning requires not only materials and books but also guidance on examination skills training from doctors and lecturers in the medical faculty directly.[4] Medical students must have sufficient skills and knowledge to become competent in the medical field.[5] Thus, the medical learning system during the Covid-19 pandemic has become a topic that has been widely studied for the last three years.

Several studies from journals, reviews, and articles show that the effectiveness of medical education will affect the national health level.[6,7] Furthermore, doctors are on the frontline of national health services, so medical students with good medical knowledge will become expert doctors in the future.[8] Due to that, we must ensure learning methods in medicine during a pandemic can distribute medical knowledge to students with the unchanged quality compared to before the pandemic occurred. So, the pandemic should not hinder the course of medical education. Therefore, a support system is needed to facilitate medical education during the Covid-19 pandemic.[9]

E-learning appears as a learning tool during pandemic.[10] E-learning is a teaching process that integrates any form of technology, it describes an educational setting in which teaching and learning takes place within an internet-based environment. E-learning is also called online learning because it requires internet to be accessed.[11,12] E-learning increases educational effectiveness and learning opportunities. Knowledge can be stored at a Web page and can be updated and maintained regularly. E-learning is part of the information and communication technology, enabling students to learn anytime and anywhere.[13]

E-learning has two types: synchronous and asynchronous.[14] Synchronous means the learning process occurs simultaneously between the educator and the learner. Therefore, it enables direct interaction between educators and learners online. Synchronous training is a picture of a real classroom, but it is virtual, and all students are connected via the internet.[15] Asynchronous means the learning process does not happen at the same time between the learner and the educator.

This e-learning type is popular because students can access learning materials anywhere and anytime. Students can carry out learning and complete it at any time according to a predetermined schedule range.[14,16] Learning can take the form of recorded videos and podcasts, reading, animation, simulation, educational games, tests, quizzes, and assignment collection. The components of e-learning are e-learning infrastructure, e-learning systems, applications, and e-learning content.[17]

Historically, there have been two common e-learning modes: distance learning and computer-assisted instruction.[18] Distance learning uses information technologies to deliver instruction to learners who are at remote locations from a central site. Computer-assisted instruction (also called computer-based learning and computer-based training) uses computers to aid in the delivery of stand-alone multimedia packages for learning and teaching. These two modes are subsumed under e-learning as the Internet becomes the integrating technology.[18]

E-learning systems and applications are often referred to as The Learning Management System (LMS), which is a software system that virtualises the conventional teaching and learning process for administration, documentation, reports of a training program, classrooms, online events, e-learning programs, and training content, for example, all features related to the management of the teaching and learning process such as how to manage the classroom, the creation of materials or, discussion forums, grading systems, online examination systems that are all axle the internet, as well as the usage of the telehealth.[19]

E-learning is beneficial for medical education in terms of knowledge, skill and attitudes.[20] One of the e-learning technologies that is currently developing is virtual reality. This technology has begun to be widely used since the pandemic. In terms of knowledge and

skills, virtual reality (VR) is a part of e-learning that has the potential to revolutionize the way students learn.[21] VR technology allows students to enter computer-generated 3D worlds and interact with them using special devices, including VR headsets. This immersive technology is increasingly popular and has a lot of potential to increase learning effectiveness by creating interactive learning modules that combine 3D graphics with real-world experiences.[22]

Virtual learning has become an important part of medical education, especially since the pandemic.[23] By using VR, anatomy teaching can be done with virtual cadavers.[24] In addition, virtual reality can be used by students to practice cardiopulmonary resuscitation skills even though they are far from the hospital and get input from instructors.[25] Research shows that VR simulations can be a useful additional learning tool for medical students.[26] In terms of attitudes, study showed that student motivation and outcomes are significantly affected by e-learning systems.[27]

However, learning using e-learning has some positive impacts, such as accessibility, flexibility, and easier feedback.[28] Some benefits of e-learning in medical education are shortening learning time, making medical students' study costs more economical, and facilitating interaction between students and materials independently. Hence, students have more control over their learning period.[29] In the context of medical education, learning with e-learning can help students to improve their medical knowledge and skills, as well as prepare them for future challenges.

However, we recognise the need for more research on e-learning in medical education.[30] Due to that, we conduct a bibliometric analysis to explore and analyse large amounts of scientific data. This article discusses the trend research, journal publication, potential topics in the future of e-learning in medical education journal publications.

In addition, the article aims to help researchers map and visualize research data related to the use of e-learning for the effective medical education in the future. Map and visualisation of the research data is important. Data visualization helps to tell stories by curating data into a form easier to understand, highlighting the trends and outliers. A good visualization tells a story, removing the noise from data and highlighting useful information. It is a technique that helps to communicate insights from data by presenting it in a way that is easy to understand, highlighting the important trends and patterns while removing irrelevant information from research data. Bibliometric analysis will be able to tell a story by presenting the data clearly and concisely, making it easier for the audience to understand the message behind the research data.[31]

METHODS

Initially, we searched the Scopus database, and the assessment of the obtained documents was divided into three phases. Based on figure 1, First phase, we determined the search criteria to identify records in the Scopus database. In the second phase, documents are exported to VOSviewer software for bibliometric analysis of journals, authors, keywords, and countries. In third phase, we analyze the data to identify the main themes discussed in the research developed on e-learning in medical education during the covid-19 pandemic.

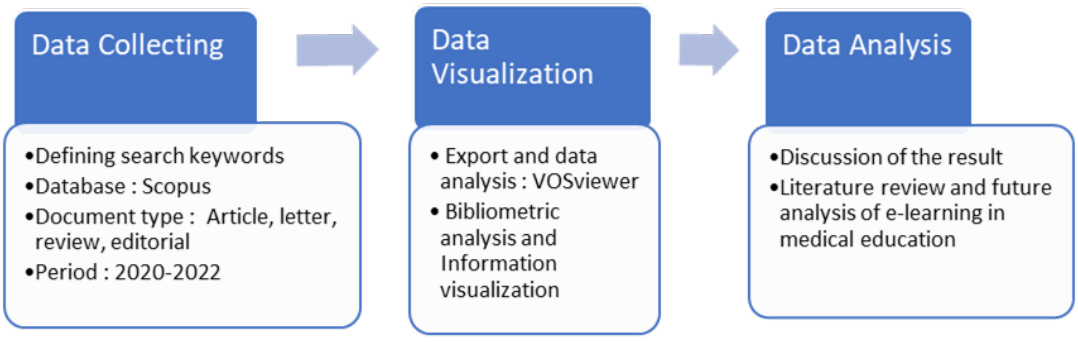

Figure 1. The Methodological Phase, Steps, and Analysis Criteria Applied to This Work

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Bibliometrics is an analytical method used to identify trends in scientific publications, encourage the creation of systematic research on a topic. Bibliometric analysis provides analysis and new perspectives for future research, and guarantee the quality of information results produced. Bibliometric analysis is an important tool for researchers and educators in relevant fields. It could helps identify the most impactful papers within a specific field of research, explore the impact of a set of researchers, or the impact of a particular paper. We collected the documents in this study from the Scopus data platform.

Scopus is an ideal database for bibliometric analysis covering information published in indexed journals in several fields of knowledge. This database has been widely used in the bibliometric analysis. We conducted this search on August 14, 2022, by inputting the keywords “e-learning” AND “medical” AND “covid”. All collected datas are exported as a "Scopus delimiting" file containing "Full cited references" used for co-authorship and cooccurrence analysis.

Thus, generating a network map of authors, countries, and keywords is possible. In addition, from the citation analysis, a network map of scientific journals is generated. VOSviewer software (version 1.6.18, Leiden University, Leiden, Netherlands) is used for mapping and visualising bibliometric networks. The output results are displayed in interlocking circles to see the relationship between the bibliometric data. The distance between two or more circles indicates the strength of the relationship between the terms represented. Different colours represent different term groups. In addition, the size of the circle is correlated with the frequency of occurrence of the term. Therefore, the number of clusters in each network map may change depending on the number of links.

RESULTS AND DISCUSSION

The Visualization of the Keywords Related to E-learning in Medical Education from Scopus Database Between 2020-2022

VOSviewer shows the network visualisation of keywords related to e-learning in medical education. Each topics were symbolised as circles. The bigger the circle, the more important the keyword is. The frequency of occurrence determines the size of the keywords. Technically, the keyword of Covid-19 was the top research topic since it has the highest frequency of occurrence, followed by the keyword of “e-learning”. Each circle has a different colour belonging to its cluster. Based on VOSviewer, there are 6 clusters of the research topic trends related to e-learning in the medical education field. The author keywords of the papers are clustered into six groups. Of the 1586 keywords, 89 keywords met the threshold. The keyword “Covid-19” appeared most, with 381 (20%) cooccurrences, followed by e-learning (181, 9,7%), medical education (181, 7,8%), education (90, 4,8%) and pandemic (68, 3,6 %).

Overlay Visualization of the Keywords using VOSviewer

The overlay visualization image illustrates the novelty of research on e-learning in medical education. VOSviewer maps that publications in Scopus related to the use of e-learning in medical education began to grow rapidly in research in 2020. VOSviewer depicts data that appeared at the beginning of 2020 in dark green. Meanwhile, data that appears in 2021 is bright yellow. Only a small amount of data is in light color. This shows that research related to the potential of e-learning in medical education is being conducted less and less as the Covid-19 pandemic is over. In fact, research related to e-learning must be developed continuously for the development of medical education.

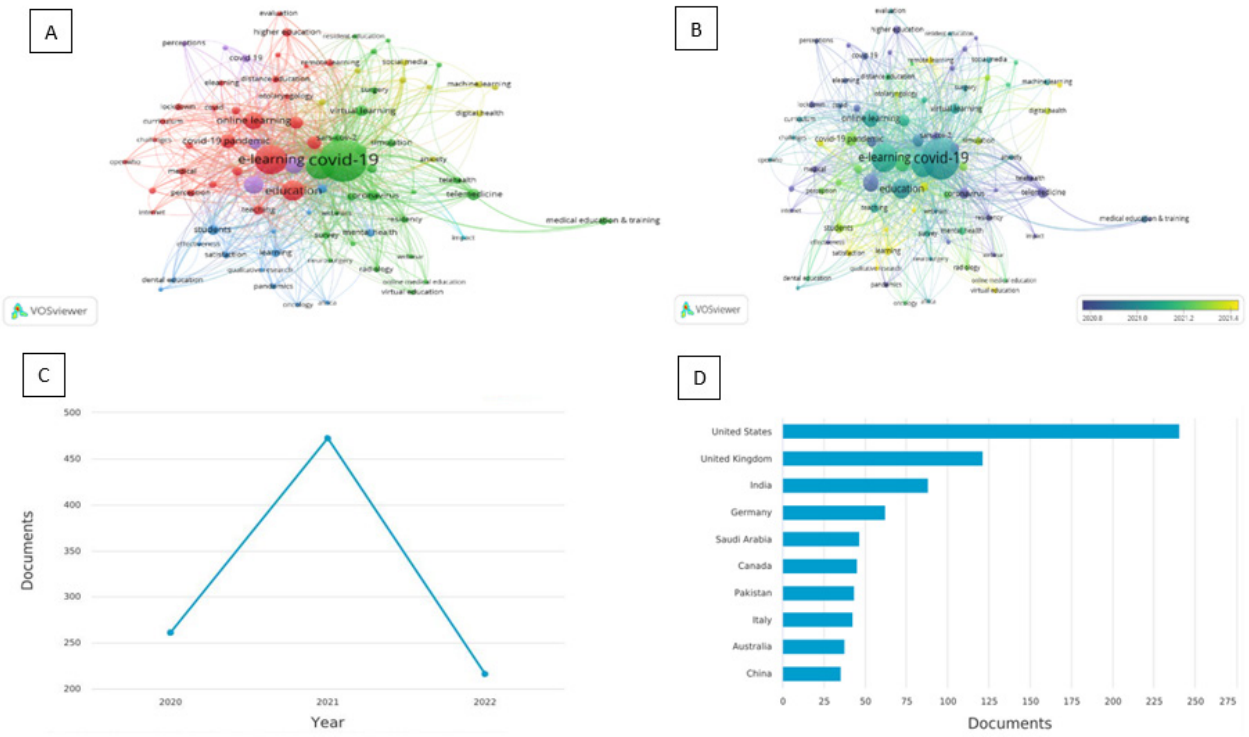

Figure 2. Network visualization of Keyword in VOSviewer (A); Overlay visualization of Keyword using VOSviewer (B); Publication trend about e-learning in medical education from Scopus database (C); Country with Most Publication related to E-learning in Medical Education in Scopus database between 2020-2022 (D)

Quantitative Analysis of the Keyword Cooccurrence Cluster

The author keywords of the papers are clustered into six groups (Table 1). Of the 1586 keywords, 89 keywords met the threshold. The keyword "Covid-19" appeared most, with 381 (20%) cooccurrences, followed by e-learning (181, 9,7%), medical education (181, 7,8%), education (90, 4,8%) and pandemic (68, 3,6 %). Publications related to e-learning in medical education during covid-19 pandemic were classified into six coloured clusters in figure 6 (a) Cluster 1 (red) involved keywords related to medical education during the pandemic, (b) Cluster 2 (green) involved keywords related to methods of e-learning in medical education, (c) Cluster 3 (blue) involved keywords related to branches of medical education that was affected during covid-19 pandemic, (d) Cluster 4 (yellow) involved keywords related to the media used in e-learning during covid-19 pandemic, (e) Cluster 5 (purple) involved keywords related to reality that Covid-19 pandemic affects medical education in certain aspects, and (f) Cluster 6 (light blue) involved keywords "impact".

The Trend Research of E-Learning in Medical Education during The Covid-19 Pandemic

Generally, research about E-learning in medical education during the Covid-19 pandemic in the scopus database started to grow for the first time since 2020 (total of 260 publications), and the research trend continues to increase in terms of the number of publications until 2021 (460 publications). The increase in journal publications during 2020-2021 was 76.9%, and the decrease in publications from 2021-2022 was 52%. The medical community needs to continue paying attention to research the implementation of e-learning in medical education as related research begins to decline.

Countries with Most Publications in Scopus Related to E-learning in Medical Education

Figure 1 shows that The United States of America (USA) has the highest number of studies and research related to e-learning in medical education during the Covid-19 Pandemic, among other countries, resulting in 240 publications (25,28%), followed by the United Kingdom with 120 documents (12,64%), India with 80 documents (8,42%), Germany with 60 documents (6,32%), and Saudi Arabia (5,05%). India and China are the only Asian country included in the top ten countries with significant numbers of e-learning in medical education research and journal publication. It means, Asian country need to conduct more research about the topics.

The Top Five of the Most Cited Articles Related to E-learning in Medical Education in Scopus Between 2020-2022

Table 1 shows the top five of the most cited articles related to e-learning in medical education during a covid-19 pandemic. The article entitled by "Advantages, Limitations, and Recommendations for Online Learning During Covid-19 Pandemic

Table 1. Top Ten Influential Articles Related to E-Learning in Medical Education

Rank	Author	Title	Year	Journal	Citation
1	Mukhtar K., Javed K., Arooj M., Sethi A.	Advantages, limitations and recommendations for online learning during covid-19 pandemic era	2020	Pakistan Journal of Medical Sciences	279
2	Dedeilia A., Sotiropoulos M.G., Hanrahan J.G., Janga D., Dedeilias P., Sideris M.	Medical and surgical education challenges and innovations in the COVID-19 era: A systematic review	2020	In Vivo	227
3	Abbasi S., Ayoob T., Malik A., Memon S.I.	Perceptions of students regarding e-learning during covid-19 at a private medical college	2020	Pakistan Journal of Medical Sciences	186
4	Al-Balas M., Al-Balas H.I., Jaber H.M., Obeidat K., Al-Balas H., Aborajooh E.A., Al-Taher R., Al-Balas B.	Distance learning in clinical medical education amid COVID-19 pandemic in Jordan: Current situation, challenges, and perspectives	2020	BMC Medical Education	160
5	Masonbrink A.R., Hurley E.	Advocating for children during the COVID-19 school closures	2020	Pediatrics	149
6	Alsoufi A., Alsuyihili A., Msherghi A., Elhadi A., Atiyah H., Ashini A., Ashwieb A., Ghula M., Ben	Impact of the COVID-19 pandemic on medical education: Medical students' knowledge, attitudes, and practices regarding electronic learning	2020	PLoS ONE	146
7	Wijesooriya N.R., Mishra V., Brand P.L.P., Rubin B.K.	COVID-19 and telehealth, education, and research adaptations	2020	Paediatric Respiratory Reviews	102
8	Bączek M., Zagańczyk-Bączek M., Szpringer M., Jaroszyński A., Wożakowska-Kapłon B.	Students' perception of online learning during the COVID-19 pandemic: A survey study of Polish medical students	2021	Medicine	95
9	Shah S., Diwan S., Kohan L., Rosenblum D., Gharibo C., Soin A.	The technological impact of COVID-19 on the future of education and health care delivery	2020	Pain Physician	80
10	Ahmady S., Kallestrup P., Mehdi M., Sadoughi.	Distance learning strategies in medical education during COVID-19: A systematic review	2021	Journal of Education and Health Promotion	53

Era" written by Mukhtar et al. (2020) has been cited 279 times representing the highest cited article overall in this field, which was published in 2020 by the Pakistan Journal of Medical Science. Meanwhile, the article entitled "Medical and Surgical Education Challenges and innovations in the COVID-19 era: A systematic review" published by In Vivo journal is in second place. The most cited articles were mostly published in 2020.

Over the past three years, distance learning in clinical medical education has been carried out due to the COVID-19 pandemic.[32,33,34] Medical education is important because it teaches the patients knowledge in the medical field and examination skills. Distance learning in medical education raises concerns about whether medical science can be absorbed and understood well by students or not.[35] Furthermore, there are numerous difficulties that both students and teachers encounter when participating in online medical education during Covid-19 pandemic.[36,37,38] In response to this problem, e-learning has emerged as a solution for medical learning.[39]

Electronic learning (e-learning) is a type of learning process that uses internet technology to facilitate, deliver, maximise, and enable distance learning to run.[40] E-learning helps to form a long-lasting digital transformation in medical education that fosters openness and communication between medical students and their instructors.[41,42] Over time, there has been considerable growth in research related to e-learning in medical education, including an increased variety of articles, reviews, and journals. In response to that, we conducted a bibliometric analysis related to e-learning in medical education during the covid-19 pandemic. Because the implementation of e-learning during the pandemic could be a source of evaluation for the medical learning system and also the development of better medical education in the future.[43,44]

We have analysed e-learning in medical education during the Covid-19 pandemic publications in Scopus. Publications on e-learning research under COVID-19 grew rapidly in 2020. When we searched medical education-related publications using the same database, we obtained as many as 949 related publications. This shows that publication on relations between e-learning, medical education, and Covid-19 research only account for 0,2% of COVID-19 research, which is a very small portion. Moreover, the trend of research between 2020 and 2022 shows an increase in journal publications during 2020-2021 (76.9%) and a decrease in publications from 2021-2022 (52%). Research related to the potential of e-learning in medical education is being conducted less and less as the Covid-19 pandemic is over.

This can be attributed to the decrease in the medical community's attention to the importance of electronic learning as the support system for the development of medical education. In fact, research related to e-learning must be developed continuously for the development of medical education. However, we still get some research hotspots through the cooccurrence clustering of keywords and gain knowledge through network visualisation maps from VOSviewer. We found that the keywords Covid-19, e-learning, and education were visualised with large circle sizes and different colours. This suggests that all three topics are important and correlated with our bibliometric analysis topic and the size of the circle displayed indicates the frequency of occurrence. The topics belong to different clusters because they have different colours.

To deepen our knowledge related to journals in the field of e-learning, we conducted a quantitative analysis on six keyword cooccurrence clusters. We get the word Covid-19 apparent the most with 20% co-occurrences, followed by e-learning, medical education, education, and pandemic. The keyword 'Covid-19' has become dominant because it has been an infectious disease for the past three years and requires deeper research through journal publications. Furthermore, the keyword medical education also often appears in this topic. This is due to the importance of medical education in developing competent doctors.[45] For future research, researchers are prioritized to take topics from keywords with a high frequency of cooccurrences. This is because the higher the frequency of keyword occurrence, the keyword mostly becomes the main topic of discussion and is related to important issues nowadays.

For the post covid era, our bibliometric research reveals that the topic about the usage of e-learning for undergraduate medical education needs further research, since e-learning has potency to improve and enrich the quality of the medical education system. E-learning is a learning method by utilizing online electronic devices. The emergency implementation of e-learning during a pandemic illustrates that e-learning can facilitate the learning process for medical students, we can even make use of it after the pandemic is over. E-learning provides a flexible learning experience for students. Students able to listen to lectures repeatedly via recordings, enabling more comprehensive learning. Through the development of electronic learning modalities for example 'virtual reality' and 'metaverse', learning does not have to be done in the classroom, but can be done remotely.[46] Examinations do not have to use paper and assessments are carried out quickly by an electronic system.[47]

Furthermore, e-learning offers several benefits, such as easy access to educational material, the ability to study in a preferred environment, and the ability to study while maintaining social distancing and continuing medical duty. E-learning can also be used to simulate emergency situations and provide direct experience to the undergraduate medical students.[48] This can help develop critical teamwork skills among them. E-learning is a promising tool for the future of medical education. It provides better access to learning resources, is beneficial for reaching dispersed audiences, and can be used to simulate emergency situations and provide direct experience to the medical students.

E-learning has a major impact on medical students in terms of knowledge, skills, and attitudes. The benefit of e-learning in the field of medical education is the use of virtual reality methods. Virtual reality is a part of e-learning. The virtual reality component consists of a virtual reality headset and a user's head position sensor. This sensor can adjust the user's head position and the virtual world. This technology allows users to enter the virtual world and carry out medical training and education activities in cyberspace.[49] From a scientific perspective, virtual reality technology can be used to deliver material on anatomy, surgery and suturing techniques. Teachers and students can enter the virtual world with virtual anatomy cadaver.[49]

In terms of skills, the teacher can model the procedure for suturing a wound virtually and then the students follow it.The use of e-learning technology in the form of virtual reality can facilitate educators to teach various skills using tools and mannequins in the virtual world.[50] Apart from that, Cardiopulmonary Resuscitation skills can also be learned using virtual reality.[25] Teachers can practice cardiopulmonary resuscitation methods using certain scenarios. Emergency incident scenarios can be created in the virtual world so that students are able to practice resuscitation skills like in the real world.[48] In terms of attitudes, students who study e-learning show an increase in learning attitudes in a positive direction. Learning attitudes are the driving force of learning behavior attitudes and motives for seeking knowledge in students.

Student learning always involves their own cognitive abilities, as well as other abilities such as: motivation, study habits, self-mastery and control, empathy and several social skills.[27] A student is said to have good study habits, if the student has a good way of learning and a learning atmosphere that supports learning. E-learning is here to create a good and interesting learning atmosphere for medical students, thereby increasing student motivation to study medical material in more depth. The material contained in e-learning can be accessed anytime and anywhere, thereby increasing student activity in learning.[27]

This bibliometric research directs teachers or researchers to research e-learning more comprehensively. So that in the future, learning using an electronic learning system can advance the medical learning system. However, there are consequences in implementing e-learning as a modality in medical learning. The Faculty of Medicine needs to conduct training on the use of online learning tools as well as student orientation.[51] Spending money to purchase premium software packages are advised since they might assist users get around several restrictions. Medical Schools are advised to purchase license for premium software to detect student cheating and plagiarism.[52]

CONCLUSIONS

This article uses some quantitative data to reinforce and call more researchers to pay attention to aspects of e-learning in medical education, as this is a field related to the development of the future health systems and healthcare providers. It is important to know that medical learning methods are important for producing competent graduates in the field of medicine.

Through bibliometric analysis and visualization methods, we came to the following conclusions: (a) The medical community needs to continue paying attention to research the implementation of e-learning in medical education as related research begins to decline since 2022, (b) Related research focuses on the use of e-learning during the pandemic shows that it also beneficial even after pandemic, (c) The United States of America still dominating this field of research, so other country need to do more research about this topic, (d) There are still several potential topics for research related to the e-learning field.

RECOMMENDATIONS

Based on our bibliometric analysis, researchers in medical education field needs to focus on how to maximize the benefits of e-learning methods in medical education in the post-covid era because e-learning methods has potency to develop a better medical education in the future.

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DECLARATION OF INTEREST

The authors declare that there are no competing interests related to the study.

AUTHORS' CONTRIBUTION

Salzha Devinta – developing research proposal, collecting data, data analysis, and publication manuscript.

Nanang Wiyono – data analysis and publication manuscript.

Yunia Hastami– developing research proposal and collecting data.

Siti Munawaroh – data analysis and collecting data.

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