Application of bibliometric analysis in the study of scientific publications on artificial intelligence in medical education

Iwona Mazur
Public Health Didactic Team, Faculty of Finances and Management, WSB Merito University,
ul. Fabryczna 29-31,53-608 Wroclaw, Poland
E-mail: iwona.mazur@umw.edu.pl
ORCID: https://orcid.org/0000-0001-5805-7569

Martyna Jończyk
Medical University of Białystok, Medical Faculty
ul. Jana Kalinowskiego 1, 15-089 Białystok, Poland
E- mail: martynaj2001@gmail.com

Julianna Noskowicz
Medical University of Białystok, Medical and Dental Studies
ul. Jana Kalinowskiego 1, 15-089 Białystok, Poland
E-mail: julianna.noskowicz@wp.pl

Natalia Przeździecka
Medical University of Białystok, Medical and Dental Studies
ul. Jana Kalinowskiego 1, 15-089 Białystok, Poland
E-mail: przezdzieckax@gmail.com

Abstract

Aim. The aim of the article is to identify and assess the main research trends regarding the use of artificial intelligence (AI) in medical education with particular emphasis on student perception based on bibliometric data of literature published in the years 1995 to 2025 in the Scopus database.

Methods. As can be seen from the considerations contained in this article, the use of bibliometric analysis can be considered an effective tool for developing a synthetic approach to current trends and challenges related to the scientific issues studied.

Results. The results obtained from the bibliometric analysis confirm the growing acceptance and effectiveness of artificial intelligence (AI) in teaching students preclinical medical competences. Studies published in the world literature provide evidence of the positive impact of AI on specific areas of students' health and the effectiveness of teaching, from dietary competences, through mental health, to biological safety in clinical settings. The researchers point to high expectations towards AI as well as the need for its responsible and ethical implemen-

tation. At the same time, the authors recommend the integration of AI taking into account the specificity of individual medical disciplines. In the researched topics, the following thematic areas were considered key: (1) Medical education and healthcare systems, (2) Distance education and digital technologies, (3) AI technologies and machine learning, (4) Man and the psychological and ethical perspective (results obtained using VOSviewer software).

Key words: artificial intelligence, student, health education, bibliometric analysis, VOSviewer

Introduction

It is hard to deny that artificial intelligence (AI) is becoming increasingly important in medical education. Research results confirm that it has great potential to revolutionise student education processes by offering, among others, modern curricula, personalised education, intelligent practical simulations or assessment of learning outcomes with immediate feedback (Sallam et al., 2023). The use of AI, especially in the form of large language models (LLM) such as ChatGPT, is finding increasing application in teaching anatomy, diagnostics and public health (Sallam et al., 2023; Abdellatif et al., 2022; Baglivo et al., 2023). This enables personalisation of teaching, automation of assessment and simulation of clinical cases in a virtual environment. On the one hand, the use of AI arouses enthusiasm, but on the other hand, concerns, especially in the context of the reliability of knowledge, ethics, or the potential replacement of human work. At the same time, it should be realised that blocking access to AI in education, e.g. for fear of plagiarism, is not a good solution. Artificial intelligence is gaining importance in medical education as a tool supporting the personalisation of teaching, analysis of large data sets, and automation of assessment processes (Lenart et al., 2025). At the same time, questions arise about its effectiveness, data security, impact on shaping students' critical thinking skills, and the risk of lowering students' analytical skills with excessive reliance on AI. Hence, knowledge on this issue seems crucial.

In connection with the above, an attempt was made to study scientific publications on artificial intelligence. The aim of the article is to identify and assess the main research trends on the use of artificial intelligence (AI) in medical education with particular emphasis on student perception based on bibliometric data of literature published in the years 1995 to 2025 in the Scopus database. The technical support for the analysis was provided by VOSviewer software, which allowed for the development of the main clusters defining the conceptual connections between artificial intelligence and medical education.

Research methodology

In order to achieve the aim of the article, a review of scientific literature was conducted, especially scientific articles containing references to the category of artificial intelligence in the education of medical students. The research procedure was as follows. First, the subject of the study was selected, i.e. the set of publications

to be analysed was determined. This was done by initially selecting the analysis criteria, time period and document types. Then, using bibliometric techniques, an analysis of the generated documents was carried out and, on this basis, an analysis of perception maps was carried out in terms of the frequency of occurrence and co-occurrence of conceptual categories. The next, fourth stage concerned the creation of publication clusters and their analysis. The fifth, last one included an analysis of the content of the most frequently cited scientific articles. Nine articles were accepted for this analysis, the citations of which ranged from 194 to 20 times. The bibliometric analysis covered the years 1995–2025. The final set of criteria is included in Table 1.

Table 1.
Scopus database selection criteria

(TITLE-ABS-KEY („artificial intelligence") I TITLE-ABS-KEY („student") I TITLE-ABS-KEY („pupil") I TITLE-ABS-KEY („health education"))

Source: author's elaboration.

As a result of applying the criteria listed in Table 1, 120 publications were obtained, the abstracts of which were the input data for developing perception maps. These maps were used to select clusters, which could be used for further in-depth bibliometric analysis. The VOSviewer tool was used to construct the maps. This software allows for indicating the relationships between multi-element data sets by creating various forms of maps, emphasising different aspects of data presentation (Grześ – Bukłaho, Kłoczko 2024; Pawelec, Jończyk 2018). In this article, the network visualisation form was chosen.

Analysis of trends in scientific publications on artificial intelligence in the education of medical students

According to the chosen procedure, first a quantitative set of results was obtained, which was presented in the form of a graph in Figure 1.

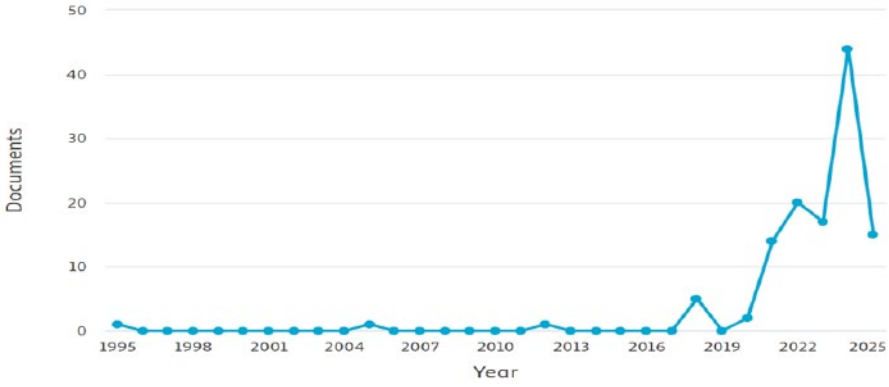

Fig. 1. Changes in the number of publications in the field of quality management of medical services in the years 2001-2017 in the Scopus database
Source: author's own study based on the Scopus database (indexed until 30/03/2025).

The analysis of the graph clearly divides publications into 2 stages of development. In the years 1995 and 2016, there are practically no scientific publications. The distribution of published items is as follows: in 1995, 2005 and 2022, 1 study was identified. Then in 2018 there are 5 items, in 2020 2 items. A significant increase in interest in the topic concerns the period from 2021 to 2025, where in 2021 14 items were published, in 2022 20 items, in 2023 17 items in 2024 already 44. A significant increase in publications is estimated for 2025 because 15 items were identified in the first quarter.

Another important aspect of the analysis was to determine the areas of science in which the issue of using artificial intelligence in the education of medical students is addressed. The list of areas along with the number of scientific publications is presented in Table 2.

Table 2.
Summary of scientific areas from the Scopus database in the years 1995-2025 related to artificial intelligence in the education of medical students

Subject area	Number of documents
Medicine	47
Computer Science	39
Social Sciences	27
Engineering	17
Mathematics	15
Environmental Science	10
Biochemistry, Genetics and Molecular Biology	7
Decision Sciences	7
Psychology	7
Health Professions	6
Nursing	6
Dentistry	4
Material Science	4
Physics and Astronomy	4
Chemical Engineering	3
Pharmacology, Toxicology and Pharmaceutics	3
Agricultural and biological Sciences	2
Chemistry	2
Immunology and Microbiology	2
Multidisciplinary	2
Neuroscience	2
Business, Management and Accounting	1
Earth and Planetary Sciences	1
Veterinary	1

Source: author's own study based on the Scopus database (indexed until 30/03/2025).

As can be seen from the data distribution, most of the publications in the Scopus database that contain the keywords: „health education", „ artificial intelligence „, „student" is assigned to 3 disciplines: Medicine (21.5%), Computer Science (17.8%) and Social Sciences (12.3%).

At the same time, it is worth paying attention to the distribution of the number of scientific publications addressing the researched issues in relation to specific types of these studies (Table 3.)

Table 3.
Summary of scientific areas from the Scopus database in the years 1995-2025 related to artificial intelligence in the education of medical students

Document type	Number of documents
Article	77
Conference Paper	16
Note	7
Review	7
Conference Review	5
Book	3
Editorial	2
Book Chapter	1
Short Survey	1
Retracted	1

Source: author's own study based on the Scopus database (indexed until 30/03/2025).

The vast majority of publications are articles (64.2%). Next in line are conference articles (13.3%), notes (5.8%), reviews (5.8%) or conference reviews (4.2%). For example, books accounted for only 2.5% and chapters in books 0.8% of all publications, which may indicate that the issue of artificial intelligence among medical students is in a phase of dynamic development.

Analysis of key topic areas regarding artificial intelligence in medical student education

Then, based on the data obtained from the Scopus database, perception maps were developed using VOSviewer software. When generating the final map of keyword co-occurrence, filtering of these words was applied and all terms that were not internally related to the main topic of the analysis, such as names of regions or typical terms such as research, survey, literature review, were removed. The obtained results are presented in the form of a perception map in Figure 2.

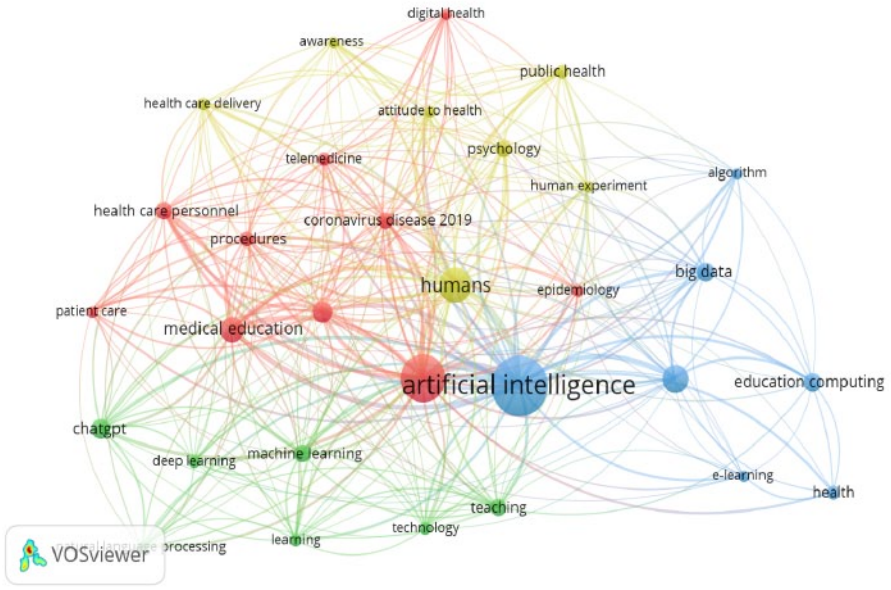

Fig. 2. Perception map
Source: author's own study based on Scopus, using the VOS-viewer program.

The analysis of Figure 2 indicates the existence of four thematic clusters, defining the main directions of research on the application of artificial intelligence (AI) in medical education of students.

The first cluster is titled "Medical Education and Healthcare Systems". This cluster focuses on the application of AI in clinical practices, health care system management and medical staff education. It covers issues related to the digitalisation of health services (e.g. telemedicine, digital health), the response of health care systems to the COVID-19 pandemic, and improving the professional competences of medical personnel. Research on the implementation of technologies in clinical education and their impact on the quality of patient care is of particular importance here. The keywords used to study the connections in this area are: medical education, medical students, health care personnel, health education, patient care, procedures, telemedicine, digital health, epidemiology, coronavirus disease 2019.

The second cluster is called "Distance Education and Digital Technologies". This cluster concerns the use of digital technologies, including AI, big data and algorithms, in medical education, especially in the context of e-learning and distance education. It also takes into account the impact of these technologies on the mental health of users and the transformation of teaching processes towards digital solutions. Works in this area analyse, among others, the effectiveness of teaching supported by artificial intelligence and the challenges related to information overload. The following terms are used as keywords: artificial intelligence, health,

mental health, big data, algorithm, education computing, e-learning.

The third cluster is called "AI Technologies and Machine Learning". This area includes fundamental AI technologies such as machine learning, deep learning, natural language processing (NLP), as well as the use of solutions such as ChatGPT. These issues are analysed both in the technological and educational context – e.g. as tools supporting the didactic process, personalisation of teaching or automation of assessment. The keywords used here are: machine learning, deep learning, chatgpt, natural language processing, teaching, learning, technology.

The fourth and last cluster is entitled: „Humans and the psychological and ethical perspective". It includes humanistic and psychological issues related to the reception and impact of AI on humans. It concerns, among others, attitudes towards new technologies, ethical aspects of experiments involving humans, as well as the level of awareness and readiness for digital changes among participants of educational and health processes. The keywords used here are: humans, psychology, public health, human experiment, awareness, attitude to health, health care delivery.

In order to deepen the bibliometric analysis, a content analysis of the seven most frequently cited scientific articles was conducted. The list of selected publications is included in Table 4.

Table 4.
Review of selected most frequently cited studies on the use of AI in medical education

Authors (year)	**Citations**	**Research methodology**	**Results**	**Recommendations**
Sallam et al. (2023)	142	Descriptive Study Using ChatGPT	Advantages (personalisation, accessibility) and disadvantages (errors, hallucinations) were indicated	Cautious but Active Introducing AI into Medical Education
Teng et al. (2022)	66	National survey (Canada), 2167 students	78.7% of students believe that AI will impact their careers	Introduction of AI basics to the curricula of all medical courses
Wang, Park (2021)	62	Designing an AI-Based Sports System, Functional Testing	Improving students' mental health	Development of personalised physical activity recommendations using AI
Monlezun et al. (2018)	48	Multicenter cohort study, 3248 students; regression analysis	Improving dietary skills; reducing the consumption of sweetened beverages	Scaling the Clinical Kitchen Teaching Model
Abdellatif et al. (2022)	35	Literature Review	AI supports anatomy learning, especially in the face of staff shortages	Using AI to teach anatomical structures
Thurzo et al. (2022)	23	Single-arm clinical trial in a dental center	No transmission of SARS-CoV-2; positive reception of the protocol	Integration of AI and Biosafety Principles in Dental Education
Baglivo et al. (2023)	20	Comparative Test of AI Chatbots and Students in Vaccination Education	AI is better at direct and scenario questions	Introducing Chatbots as Educational Tools

Source: author's own study based on the Scopus database (indexed until 30/03/2025).

The analysis of this short literature review indicates a growing interest in the use of artificial intelligence (AI) in various aspects of medical education. Among the most frequently cited studies, both empirical research projects and literature reviews dominate, which indicates the dynamic development of this area. Empirical studies (Monlezun et al., 2018; Wang, Park 2021; Thurzo et al., 2022) provide evidence of the positive impact of AI on specific areas of students' health and the effectiveness of teaching - from dietary competences, through mental health, to biosafety in clinical settings. In turn, the results of comparative tests (Baglivo et al., 2023) indicate the advantage of AI chatbots over students in terms of knowledge about vaccinations, which emphasises the potential of these tools as interactive didactic elements. An important thread that appears in several publications (Abdellatif et al., 2022; Teng et al., 2022; Sallam et al., 2023) is the need to integrate AI into curricula, especially in the context of learning complex anatomical structures or personalising education. However, the authors also emphasise the need to be cautious about the limitations of the technology, such as the risk of errors and the so-called „hallucinations" of generative language models.

Conclusions and limitations

This article aimed to attempt to diagnose the main research trends on artificial intelligence in the education of medical students using bibliometric analysis. It can be considered that the goal has been achieved. The main trends in scientific research on the above issues were identified and assessed based on bibliometric data of literature published in the years 1995 to 2025 in the Scopus database. The analyses carried out indicate that since 2018 this has been a very dynamically developing area of research, as indicated by, among others, the number of publications, the multiplicity and interdisciplinarity of scientific areas regarding AI in medical education. It can therefore be stated that the results obtained from the bibliometric analysis confirm the growing acceptance and effectiveness of artificial intelligence (AI) in teaching students preclinical medical competences. Studies published in the world literature provide evidence of the positive impact of AI on specific areas of students' health and the effectiveness of teaching, from dietary competences, through mental health, to biological safety in clinical conditions. Researchers indicate high expectations towards AI and the need for its responsible and ethical implementation. At the same time, the authors recommend AI integration that takes into account the specificity of individual medical disciplines. The results of the numerical review of publications were used to determine the main publication trends regarding artificial intelligence in medical education. Analysis of the co-occurrence of keywords from the Scopus database based on VOSviewer software allowed us to distinguish four dominant thematic clusters in the studied area . The first one: Medical education and healthcare systems includes the implementation of AI in healthcare systems and clinical education, focusing on improving the quality of patient care and improving the professional competences of medical workers. The second area: Remote education and digital technologies

refers to digital technologies in remote learning, paying attention to the use of big data, e-learning and the impact of intensive digitisation on the mental health of students and academic staff. The third cluster: AI technologies and machine learning emphasises the development of fundamental AI technologies, such as machine learning, deep learning and natural language processing, with a growing interest in tools such as ChatGPT in didactics and personalisation of teaching. The fourth area: Humans and the psychological and ethical perspective emphasises the psychological and ethical aspects of using AI, especially users' attitudes towards technology and issues related to experiments on humans.

At the same time, it is worth emphasising that although the conducted study contributes to the development of knowledge on AI in medical education, the applied bibliometric analysis is not free from limitations, e.g. resulting from the very nature of bibliometric studies, the use of a single database to select publications or entering specific phrases in the search field. Weaknesses also result from the omission of gray literature and the need to limit the number of characters in the publication, which is why the authors gave up on some analyses, e.g. other numerical analyses presenting the scope of publications by country, research centres or keyword maps. Despite this, it can be stated that the conducted analysis and its results can be a starting point not only for researchers interested in AI in the education of medical students, but also for researchers involved in a systematic review of literature in other fields. At the same time, it is worth emphasising that the authors' ambition is to continue the undertaken topic in the form of empirical research (quantitative and qualitative) among both students and academic teachers, especially in medical and dental fields.

Summary

Modern medical education is on the threshold of significant changes resulting from the dynamic development of artificial intelligence (AI) and related technologies. The COVID-19 pandemic, the growing importance of personalised medicine, and the need to process large data sets faster have prompted the academic community to more intensively implement digital solutions in the education process. In light of the above, there is an urgent need for systematic, multidisciplinary research, covering technological, didactic, and psychosocial aspects . Since the number of publications on AI in medical education is growing very rapidly from month to month, it is difficult to imagine conducting a literature review of the subject without using appropriate techniques dedicated to the analysis of collected data contained in available bibliographic databases. This article was an attempt to show the possibilities of using bibliometric analysis. It seems that it justifies the effectiveness of using such analyses in the systematic evaluation of extensive sources of information, which on the one hand are a great challenge for scientists, and on the other hand can create serious difficulties in the work of an individual seeking the truth about the reality being studied.

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