Research Article / Araştırma Makalesi
doi: 10.18678/dtfd.1410276

Duzce Med J, 2024;26(1):44-55
Düzce Tıp Fak Derg, 2024;26(1):44-55

Medical Informatics as a Concept and Field-Based Medical Informatics Research: The Case of Turkey

Kavramsal Olarak Tıbbi Bilişim ve Alan Bazlı Tıp Bilişimi Araştırmaları: Türkiye Örneği

Muhammet DAMAR[1]
0000-0002-3985-3073
Tuncay KÜME[2]
0000-0003-3440-3513
İbrahim YÜKSEL[3]
0000-0002-6323-8337
Ali Emre ÇETİNKOL[4]
0000-0002-0694-6871
Jiban K. PAL[5]
0000-0002-2870-9180
Fatih Safa ERENAY[6]
0000-0002-3408-0366

[1]Upstream Lab, MAP/Centre for Urban Health Solutions, Li Ka Shing Knowledge Institute, Unity Health Toronto, Toronto, ON, Canada

[2]Department of Medical Biochemistry, Dokuz Eylül University Faculty of Medicine, İzmir, Türkiye

[3]PhD in Management, Dokuz Eylül University Research and Application Hospital, İzmir, Türkiye

[4]Department of Public Health, İzmir Health Directorate, İzmir, Türkiye

[5]Division of Library Documentation and Information Science, Indian Statistical Institute, Kolkata, India

[6]Department of Management Science and Engineering, University of Waterloo, Waterloo, ON, Canada

Corresponding Author
Sorumlu Yazar
Muhammet DAMAR
muhammet.damar@deu.edu.tr

Received / Geliş Tarihi : 27.12.2023
Accepted / Kabul Tarihi : 20.03.2024
Available Online / Çevrimiçi Yayın Tarihi : 09.04.2024

ABSTRACT

Aim: This study aimed to evaluate the position of Turkey in the field of Medical Informatics and assess the general structure of research by analyzing Medical Informatics research with bibliometric methods.
Material and Methods: In this study, we conducted a bibliometric analysis of research and review articles generated between 1980 and 2023 from the Web of Science bibliometric data source, utilizing bibliometric methods through the R bibliometrix tool and VosViewer.
Results: In the field of medical informatics research in Turkey, the country holds the 27th position with 905 articles, 15,610 citations, and an impressive impact factor of 51, along with an average citation rate of 17.25 per article, based on bibliometric analysis conducted between 1980 and 2023. Notable institutions in this field include Middle East Technical University, Hacettepe University, and Selçuk University. The prominent research topics encompass "neural network(s), machine learning, support vector, health care, decision support, deep learning, EEG signals, classification accuracy," reflecting the areas of intensive investigation.
Conclusion: In Turkey, the field of medical informatics has lagged slightly behind basic engineering sciences or medical sciences. The domain exhibits a multidisciplinary structure intersecting with various engineering fields such as computer science, software engineering, industrial engineering, artificial intelligence engineering, and electronic engineering. To enhance productivity in this field, greater collaboration with other research areas can be pursued. Additionally, it is recommended to urgently establish four-year undergraduate programs specifically dedicated to medical informatics or health informatics at universities.
Keywords: Turkey; medical informatics; scientific productivity; bibliometrics; citation analysis.

ÖZ

Amaç: Bu çalışmada, Tıp Bilişimi araştırmalarını bibliyometrik yöntemler ile analiz ederek Türkiye'nin Tıp Bilişimi alanındaki konumunu ve araştırma genel yapısını değerlendirmeyi amaçlanmıştır.
Gereç ve Yöntemler: Bu çalışmada, R bibliyometrix ve VosViewer aracılığı ile Web of Science bibliyometrik veri kaynağından 1980 ile 2023 yılları arasında üretilen araştırma ve derleme türündeki makaleler bibliyometrik yöntemler ile analiz edilmiştir.
Bulgular: Türkiye tıp bilişimi araştırma alanında, 1980 ile 2023 yılları arasında yapılan bibliyometrik analize göre, 905 makale, 15610 atıf ve ilgili makalelere verilen 17,25 atıf ortalaması, 51 gibi yüksek bir etki değeri ile 27. sırada yer almaktadır. İlgili alanda öne çıkan kurumlar arasında, Ortadoğu Teknik Üniversitesi, Hacettepe Üniversitesi ve Selçuk Üniversitesi bulunmaktadır. Öne çıkan araştırma konuları arasında yoğun araştırma alanlarını yansıtan "sinir ağları, makine öğrenimi, destek vektörü, sağlık hizmetleri, karar desteği, derin öğrenme, EEG sinyalleri, sınıflandırma doğruluğu" yer almaktadır.
Sonuç: Türkiye'de tıp bilişimi uzmanlık alanı temel mühendislik bilimlerine veya tıp bilimlerine göre biraz daha geride kalmıştır. Alanın bilgisayar bilimleri, yazılım mühendisliği, endüstri mühendisliği, yapay zekâ mühendisliği ve elektronik mühendisliği gibi pek çok farklı mühendislik alanı ile kesişen multidisipliner bir dokusu mevcuttur. Bu alanda daha etkin üretkenlik için alanın diğer araştırma alanları ile daha fazla ilişkiye geçilebilir. Ayrıca tıp bilişimi veya sağlık bilişimine ilişkin ivedi olarak dört yıllık lisans programlarının üniversitelerde kurulması önerilmektedir.
Anahtar kelimeler: Türkiye; tıp bilişimi; bilimsel üretkenlik; bibliyometri; atıf analizi.

INTRODUCTION

The adoption rate of novel information and informatics technologies, such as artificial intelligence, machine learning, big data, blockchain, cloud computing, wearable and implantable technologies, virtual and augmented reality technologies, and mobile health applications is on the rise in the healthcare sector. These technologies offer numerous new advantages and opportunities, advancing the healthcare sector. However, the need for complex hardware and training of the medical staff to use these technologies is also increasing over time (1). The discipline of medical informatics plays a significant role in this context.

According to Masic (2), after its appearance around the 1950s, medical informatics is recognized as a scientific discipline that deals with the theory and practice of information processes in medicine, incorporating information technologies and data communication, particularly focusing on computers as a significant tool for information processing and analysis. Medical informatics encompasses the examination and implementation of methods aimed at improving the management (i.e., security, storage, cleaning) and analysis of patient data, clinical information, population data, and other information related to patient care as well as developing medical decision support systems (3). This represents a field that aims to enhance patient care through the management of information in the healthcare sector and the utilization of technological advancements.

Lincoln (4) highlights the reliance of medical informatics on a range of general disciplines, including logic, mathematics, computer science, and behavioral sciences as well as focused fields like decision theory, artificial intelligence, systems analysis, and industrial psychology. Haux (5) also underscores the interdisciplinary nature of medical informatics and asserts that medical informatics is instrumental in the future of medicine and healthcare services. The progression of medical informatics hinges on the presence of well-educated healthcare professionals specializing in medical informatics. These professionals may encompass doctors, nurses, healthcare managers, medical informatics specialists, or individuals from related fields.

In the delivery of high-quality and efficient healthcare services, medical informatics bears a significant responsibility for advancing human health through innovative research in health and computer sciences related to biomedicine (6). Therefore, medical informatics education is crucial for medical and healthcare services students, who are the future of the healthcare profession. In addition, medical informatics provides valuable learning resources for the continuous professional development of clinicians to keep up with the rapid advancements in the field (7). Medical informatics education is also essential for other healthcare personnel at all levels of care delivery. Therefore, in Europe, many universities have curricula in the field of medical informatics. For instance, in Germany, there are medical informatics undergraduate programs at 14 universities (8). In Turkey, there is currently no undergraduate program in the field of medical informatics. However, many universities in the country are opening graduate-level programs and establishing departments in the related field. This highlights a growing attendance and interest in education on medical informatics.

There is a natural feedback loop between advances in medical informatics and its education: the former provides education materials for the latter and the latter contributes to the training of the professionals who achieve the former. Therefore, understanding the standing of a country in advancing medical informatics has direct implications for the country's strengths and needs in medical informatics education. Thus, our study's primary objective is to examine the volume of medical informatics research conducted by researchers in Turkish institutions using bibliometric methods. Our bibliometric analysis provides a detailed overview of the bibliographic structure of publications, the positioning of Turkish researchers in the global landscape, and the prominent topics addressed in the publications, which will shed light on the need for improvements in medical informatics research and education in Turkey.

The examination of relevant literature reveals several review studies focusing on the development of health informatics in Turkey. These studies cover various aspects of health informatics; the academic evaluation of the development of health informatics in Turkey, discussions on health informatics and the digitization of hospitals in Turkey, evaluation of the development of the health informatics infrastructure in the public domain in Turkey, discussions on nursing informatics within the field of health informatics, assessments of legal issues in health informatics, evaluations of e-health applications, discussions on the importance of health informatics systems in increasing hospital efficiency, and highlighting the significance of information systems for the healthcare sector (1,9-14). In addition, there are several international bibliometric articles in the field of medical informatics, which extensively study certain relevant topics including mobile health, artificial intelligence in healthcare, augmented reality in medicine, natural language processing in medical research, highly cited articles in the field of healthcare sciences and services, telemedicine, machine learning, virtual reality, and augmented reality (15-25).

Nevertheless, the above literature reviews and international bibliometric studies do not address issues related to the scientific productivity of Turkish institutions in the medical informatics field. Our study aims to fill this gap by conducting a bibliometric analysis of national and international publications of the Web of Science (WoS) sources. Our results provide insights into the general structure of scientific productivity among Turkish researchers in the field of medical informatics. Our study may be of value to the existing and new researchers in the field for highlighting prominent medical informatics researchers, institutions, countries, journals, and works in the field.

MATERIAL AND METHODS

In this study, bibliometric data were retrieved from the WoS (Clarivate Analytics Corporations, London, UK) bibliometric data source on November 4, 2023, using the query specified for the field of medical informatics (wc="Medical Informatics" and TURKIYE or TURKEY, Countries/Regions). The number of articles produced in the field of medical informatics is 95,948 in all years. When examining the scientific productivity of studies with

Turkish affiliations by years, articles addressed to two different country names, Turkiye (*f*:79) and Turkey (*f*:826), were filtered. A total of 905 articles, categorized as research articles and reviews, published in English between 1980 and 2023, were analyzed using bibliometric methods. The reason why only article and review article types are included in the analysis is that the relevant document types have richer data features for bibliometric analysis than book chapters, proceeding papers, and letters. Within the scope of the analyses, various statistics were obtained from the dataset, including the intensity of publications over the years, country distributions, most preferred and cited journals, leading authors and institutions in the field, and keyword distributions.

Journals in the WoS belong to the Arts & Humanities Citation Index (A&HCI), Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI), or Emerging Sources Citation Index (ESCI). The journals in these indexes are widely recognized by the global scientific community and are considered a priority in academic performance criteria. Therefore, it is reasonable to assume that a significant academic advance in the medical informatics field would eventually lead to a publication in a journal in these indexes. Thus, focusing on the WoS bibliometric database for our study enables access to a high-quality and rich dataset for capturing prominent research studies shaping this field.

VOSviewer and Biblioshiny (within the R Bibliometrix) programs were utilized during the analysis process, particularly for constructing network structures and detailed tables based on the demographic characteristics of articles. VOSviewer, Bibexcel, Citespace, HistCite, Pajek, UCINET, VIVO, and Sci2 are software applications commonly employed for social network analyses (26). These software tools are for creating and visualizing bibliometric networks encompassing journals, researchers, or individual publications, which can be constructed based on citation, bibliographic coupling, co-citation, or co-authorship relationships (27). Biblioshiny, on the other hand, is another software designed with the R programming language, operating with the bibliometrix library (28). Additionally, a web-based application was developed using Hypertext Preprocessor (PHP) programming language to parse WoS data and transfer it to a database designed in Oracle. This facilitated the filtering of studies based on summary information, title, keywords, and the titles of the studies. Consequently, text analyses were also conducted as part of the study.

RESULTS

Medical Informatics Research Area General View and Turkey

Throughout all years, international institutions produced 145,523 scientific contributions of various forms in medical informatics: Original articles (*f*:90,527, 62.20%), proceeding papers (*f*:41,254, 28.34%), editorial materials (*f*:5,871, 4.03%), review articles (*f*:5,421, 3.72%), book chapters (*f*:3,858, 2.65%), meeting abstracts (*f*:2,816, 1.93%), letters (*f*:1,671, 1.14%) and others (*f*:3,559, 2.44%). Our study considers only original articles and review articles, totaling 95,948 contributions. The productivity of relevant articles by country is shown in Table 1.

When examining the country-specific scientific productivity, we combined research affiliated with the country names of "Turkiye" (*f*:79) and "Turkey" (*f*:826) to reflect the recent name change. Among all countries with scientific contributions to medical informatics, Turkey ranks 27th (Table 1) with 905 articles, which were all published in English.

Table 2 shows the distribution of the 1271 contributions affiliated with Turkey according to publication types. Original articles and proceeding papers together constitute a vast majority of all contributions (i.e., 96.30%). The review articles' contributions follow the top three with a much lower proportion of 1.57%, while the proportion of the remaining contribution types is limited to 4.24%. It should be noted that WoS can classify the same document into more than one type. For example, an article can also be classified as a proceeding paper or book chapter.

As mentioned before, original article and review article types were examined in our study. Figure 1 illustrates a citation analysis showing that a total of 905 articles affiliated with Turkey have received 15,610 citations, and these documents have a high impact value of 51. The document average age is 7.44. Articles in the field of medical informatics affiliated with Turkey have been referenced by

Table 1. Country settings in original articles and review articles on medical informatics

Rank	Country	n	% of 95,948
1	USA	35,718	37.61
2	ENGLAND	9,370	9.86
3	CHINA	7,370	7.76
4	GERMANY	7,370	7.76
5	CANADA	6,113	6.43
6	AUSTRALIA	5,062	5.33
7	NETHERLANDS	4,428	4.66
8	SPAIN	3,163	3.33
9	ITALY	3,160	3.32
10	FRANCE	3,062	3.22
11	SOUTH KOREA	2,384	2.51
12	INDIA	2,223	2.34
13	JAPAN	2,212	2.33
14	SWEDEN	2,123	2.23
15	SWITZERLAND	1,994	2.10
16	TAIWAN	1,922	2.00
17	BELGIUM	1,503	1.56
18	AUSTRIA	1,303	1.35
19	SCOTLAND	1,211	1.26
20	DENMARK	1,202	1.25
21	BRAZIL	1,142	1.19
22	NORWAY	1,128	1.17
23	IRAN	1,116	1.16
24	SINGAPORE	1,116	1.16
25	FINLAND	1,113	1.16
26	GREECE	1,088	1.13
27	TURKEY	905	0.94
28	ISRAEL	852	0.88
29	PORTUGAL	838	0.87
30	NEW ZEALAND	642	0.66

Table 2. The distribution of documents by type

Rank	Document Type	n	% of 1,271
1	Original Article	885	69.63
2	Proceeding Paper	347	27.30
3	Review Article	20	1.57
4	Early Access	15	1.18
5	Book Chapters	12	0.94
6	Correction	10	0.78
7	Editorial Material	10	0.78
8	Letter	5	0.39
9	Meeting Abstract	1	0.07
10	Note	1	0.07

30,028 sources. There is an increasing productivity in article publications over the years. When the documents associated with the field of medical informatics from Turkey are analyzed according to all document types, 2018 was the most productive year with 140 documents, showing a 212% increase compared to the previous year (66 documents were produced in 2017). When focusing on 2018, the primary reason for this increase can be attributed to documents in the "proceedings paper" category. The significant impact of the Medical Technologies National Congress (TIPTEKNO), held in 2018 and indexed by the Web of Science Conference Proceedings Citation Index - Science (CPCI-S), is noted.

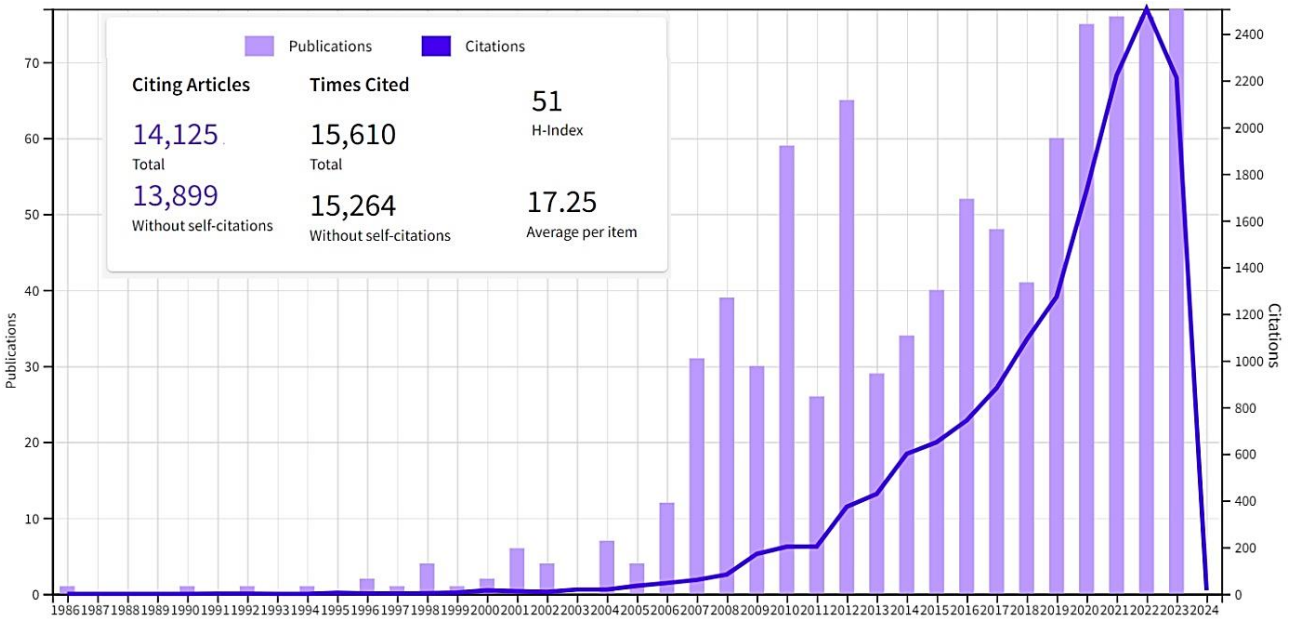

Figure 1. Publications cited over time

The distribution of the 905 scientific contributions in terms of the journal indexes is as follows: SCI-Expanded (*f*:849), SSCI (*f*:155), ESCI (*f*:38). Additionally, 21.76% of the studies have been published as open access. The years 2023 (*f*:77), 2022 (*f*:76), 2021 (*f*:76), and 2020 (*f*:75) stand out as the most productive years. In terms of funding sources, the top ten institutions that have supported the publications affiliated with Turkey are, in order: Turkey Scientific and Technological Research Institution (TUBITAK, *f*:80), Selcuk University (*f*:20), United States National Institutes of Health (NIH, *f*:20), United States Department of Health Human Services (*f*:20), European Union (EU, *f*:17), Bogazici University (*f*:11), Istanbul University (*f*:11), Akdeniz University (*f*:10), EU Joint Research Centre (*f*:10), Yildiz Technical University (*f*:6).

Authors, Institutions, and Country Analyses

Considered articles affiliated with Turkey have been produced by researchers from 72 different countries, 997 different institutions, and 2666 researchers. The top five most productive researchers, their institutional information, h-index (HI), Average Citation Per Document (ACPD), total citations (TC), and article count (N) are shown: Sadik Kara (Erciyes University, *f*:9, ACPD:12.00, TC:228, N:19), Sengur Abdulkadir (Fırat University, *f*:14, ACPD:35.72, TC:643, N:18), Inan Güler (Gazi University, *f*:7, ACPD:36.77, TC:478, N:13), Asuman Doğaç (Middle East Technical University, *f*:9, ACPD:19.27, TC:212, N:11), Fatma Latifoğlu (Erciyes University, *f*:6, ACPD:12.82, TC:141, N:11). The number of single-authored documents is 71, the international co-authorship rate is 25.76%, and the co-authors per document value is 3.88.

Figure 2, shows the collaboration network (i.e., collaborating researchers, institutions, and countries in medical informatics publications affiliated with Turkey. The top ten countries with the highest rate of collaboration with Turkish institutions for publishing articles in medical informatics are the USA (*f*:97, 10.71%), England (*f*:24, 2.65%), Germany (f:22, 2.43%), Canada (*f*:21, 2.32%), France (*f*:20, 2.21%), Netherlands (*f*:20, 2.21%), Australia (*f*:17, 1.87%), Italy (*f*:17, 1.87%), Spain (*f*:15, 1.65%), and India (*f*:14, 1.54%). The most intensively collaborated institutions in the United States are the University of Wisconsin (*f*:9), Harvard University (*f*:8), and Stanford University (*f*:6), which are the pioneering institutions in this field. In Turkey, the institutions that have collaborated intensively with the aforementioned universities are Akdeniz University (*f*:6) and Hacettepe University (*f*:12).

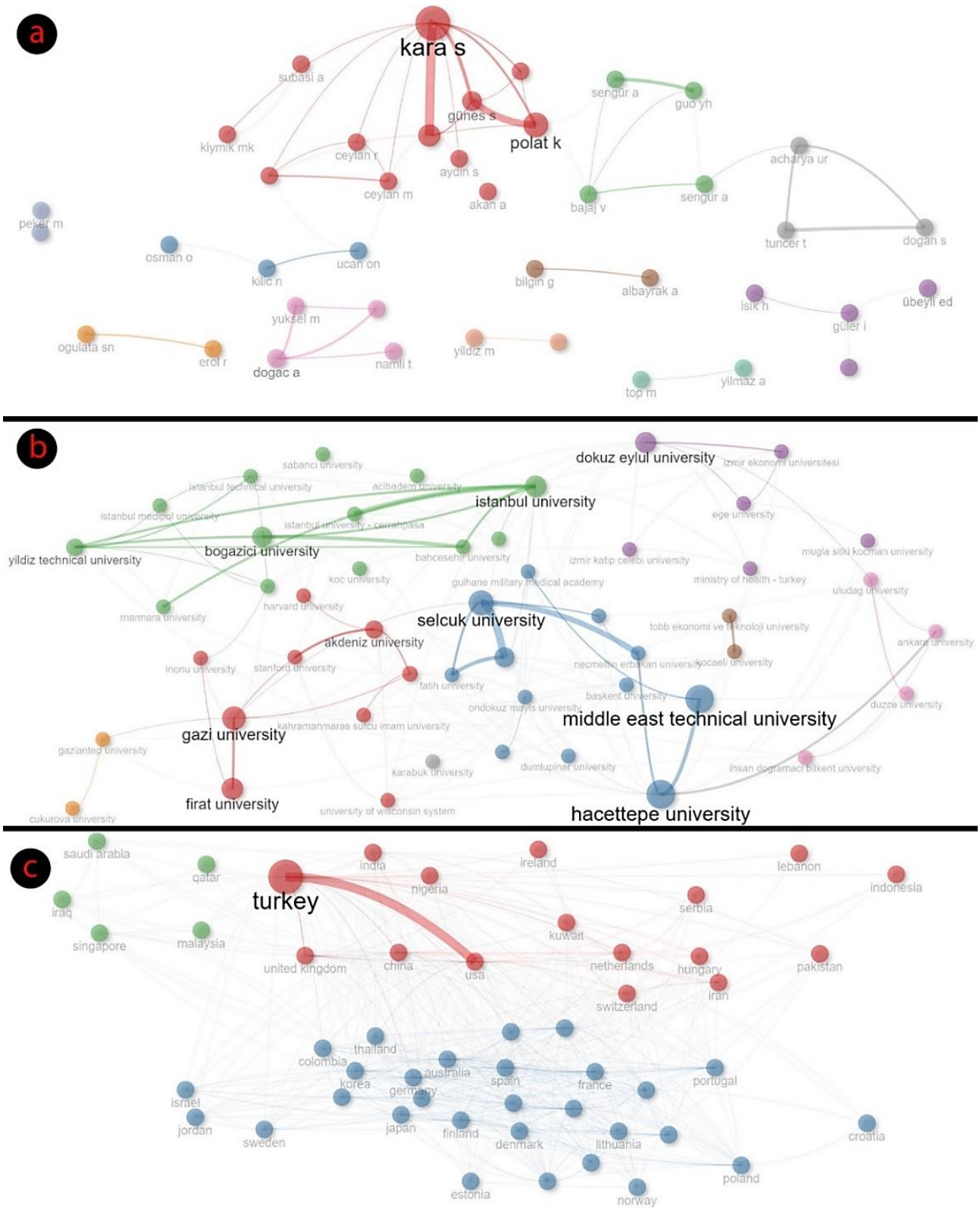

Figure 2. Author (a), affiliation (b), and country (c) collaboration analyses

The top five institutions with the most intensive international cooperation among all institutions are Fırat University (*f*:23), Middle East Technical University (*f*:22), Hacettepe University (*f*:21), Akdeniz University (*f*:12), Bogazici University (*f*:11), respectively. The institutions with the most intense collaboration in the United Kingdom are the University of London (*f*:8), Queen Mary University London (*f*:3), and University of Southampton (*f*:3). In Germany, the most intensively collaborated institutions are Institut National De La Sante Et De La Recherche Medicale (*f*:3) and Hannover Medical School (*f*:3).

Table 3 shows the Turkish institutions that produce the most article publications in medical informatics. The top five institutions are, respectively, Middle East Technical

Institution (*f*:65), Hacettepe University (*f*:63), Selcuk University (*f*:47), Fırat University (*f*:46), and Gazi University (*f*:46). The vast majority of the below institutions have their faculties of medicine as the presence of a medical faculty significantly improves the productivity of studies in medical informatics. Interestingly, the Middle East Technical University and Bogazici University, ranked first and seventh, respectively, do not have medical faculties. This is an important issue to be examined. When the scientific productivity of the Middle East Technical University is examined in detail, the influence of programs such as the faculty of engineering (*f*:27), department of computer engineering (*f*:18), graduate school of informatics (*f*:6), faculty of arts and sciences (*f*:5), department of electrical and electronics engineering (*f*:5), and department of statistics (*f*:5) becomes apparent.

Journal Analysis

Table 4 illustrates the journals publishing most medical informatics articles from Turkey. The 905 medical informatics articles are published in 57 different journals. Most of the top 20 journals have high HI and citations per document. These journals are in the first and second quartiles journals of medical informatics research area in WoS categories. These journals are mostly indexed in the Science Citation Index Expanded (SCIE), i.e., 19 out of the

Table 3. The distribution of articles and reviews addressed to Turkey by institutions

Rank	Affiliation	HI	ACPD	TC	N	% of 905
1	Middle East Technical University	15	9.95	647	65	7.18
2	Hacettepe University	17	23.24	1,464	63	6.96
3	Selcuk University	17	15.21	715	47	5.19
4	Fırat University	24	32.59	1,499	46	5.08
5	Gazi University	16	24.85	1,143	46	5.08
6	Dokuz Eylül University	15	19.02	780	41	4.53
7	Bogazici University	13	24.37	926	38	4.19
8	Erciyes University	13	13.56	488	36	3.97
9	Akdeniz University	9	6.79	224	33	3.64
10	Istanbul University	12	23.79	785	33	3.64
11	Yıldız Technical University	11	11.93	322	27	2.98
12	Sakarya University	9	13.27	345	26	2.87
13	Ege University	12	21.24	531	25	2.76
14	Tobb Ekonomi ve Teknoloji University	11	24.96	574	23	2.54
15	Cukurova University	12	19.50	429	22	2.43
16	Baskent University	9	9.48	199	21	2.32
17	Istanbul Technical University	10	20.71	435	21	2.32
18	Bahcesehir University	10	35.70	714	20	2.21
19	Karadeniz Technical University	9	14.11	254	18	1.98
20	Istanbul University Cerrahpasa	9	31.88	542	17	1.87

HI: h-index, ACPD: average citation per document, TC: total citations, N: article count

Table 4. Top 20 journals publishing most medical informatics articles affiliated with Turkey

Rank	Publication Title	5JIF	Index	Q	HI	ACPD	TC	N	% 905
1	Journal of Medical Systems	5.200	SCIE	Q2	33	17.86	3,840	215	23.75
2	Computer Methods and Programs in Biomedicine	6.100	SCIE	Q2	33	49.39	7,952	161	17.79
3	Medical Biological Engineering Computing	3.100	SCIE	Q3	17	10.39	1,018	98	10.82
4	Biomedical Engineering Biomedizinische Technik	1.600	SCIE	Q4	6	3.39	129	38	4.19
5	Computers Informatics Nursing	2.000	SCIE	Q4	11	8.81	317	36	3.97
6	Artificial Intelligence in Medicine	7.400	SCIE	Q1	13	21.10	633	30	3.31
7	IEEE Journal of Biomedical and Health Informatics	7.700	SCIE	Q1	13	34.24	993	29	3.20
8	Journal of Evaluation in Clinical Practice	2.500	SCIE	Q4	9	8.54	239	28	3.09
9	Journal of Biomedical Informatics	6.900	SCIE	Q2	14	28.54	742	26	2.87
10	IEEE Transactions on Information Technology in Biomedicine	2.873	SCIE	Q1	12	37.58	714	19	2.09
11	International Journal of Medical Informatics	5.400	SCIE	Q2	8	9.70	194	20	2.21
12	BMC Medical Informatics and Decision Making	3.900	SCIE	Q3	8	11.31	181	16	1.76
13	Health and Technology	2.300	ESCI	Q4	6	4.79	67	14	1.54
14	Health Information Science and Systems	5.700	SCIE	Q1	9	33.46	435	13	1.43
15	Journal of Medical Internet Research	7.600	SCIE	Q1	9	18.15	236	13	1.43
16	International Journal of Technology Assessment in Health Care	2.600	SCIE	Q3	6	6.75	81	12	1.32
17	Methods of Information in Medicine	2.500	SCIE	Q4	8	12.58	151	12	1.32
18	Digital Health	4.400	SCIE	Q2	2	2.00	24	12	1.32
19	Informatics for Health Social Care	2.900	SCIE	Q4	5	10.80	108	10	1.10
20	Health Informatics Journal	3.000	SCIE	Q3	4	5.10	51	10	1.10

JIF: journal impact factor, SCIE: science citation index expanded, ESCI: emerging sources citation index, Q: quartile, HI: h-index, ACPD: average citation per document, TC: total citations, N: article count

top 20 journals are indexed in SCIE. It is seen that five journals are in the first quartile, five journals are in the second quartile, four journals are in the third quartile, and finally, six journals are in the fourth quartile. The top three journals are the Journal of Medical Systems (*f*:215, 23.75%), Computer Methods and Programs in Biomedicine (*f*:161, 17.79%), and Medical Biological Engineering Computing (*f*:98, 10.82%). These three journals have published around one out of every two medical informatics articles from Turkey (474 documents, 52.37% of total publications).

Table 5 displays the top fifteen articles with the highest citations in the field of medical informatics with Turkey affiliation. Eight of the top fifteen articles with the highest citations were published in Computer Methods and Programs in Biomedicine, while each of the remaining seven was published in a different journal. Also, note that six of the top fifteen articles were on developing general-purpose bioinformatics methodology, while the remaining nine were on informatics analysis and methods for specific medical conditions.

Research Areas and Content Analysis

Medical informatics articles affiliated with Turkey have been associated with 21 different research areas listed in the Web of Science. The top five of these research areas are computer science interdisciplinary applications (*f*:379,

Table 5. The first 15 articles with the highest number of citations published in the field of medical informatics research in Turkey

Rank	Authors / Title / Journal	5JIF	Q	Years	TC
1	Stijnen T, Hamza TH, Ozdemir P Random effects meta-analysis of event outcome in the framework of the generalized linear mixed model with applications in sparse data Statistics in Medicine	2.700	Q4	2010	418
2	Sakar BE, Isenkul ME, Sakar CO, Sertbas A, Gurgen F, Delil S, Apaydin H, Kursun O Collection and analysis of a Parkinson speech dataset with multiple types of sound recordings IEEE Journal of Biomedical and Health Informatics	7.700	Q1	2013	329
3	Subasi A, Ercelebi E Classification of EEG signals using neural network and logistic regression Computer Methods and Programs in Biomedicine	6.100	Q1	2005	322
4	Guler I, Ubeyli ED Multiclass support vector machines for EEG-signals classification IEEE Transactions on Information Technology in Biomedicine	2.873	Q1	2007	245
5	Yildirim O, Baloglu UB, Tan RS, Ciaccio EJ, Acharya UR A new approach for arrhythmia classification using deep-coded features and LSTM networks Computer Methods and Programs in Biomedicine	6.100	Q1	2019	188
6	Sen B, Peker M, Çavusoglu A, Çelebi FV A comparative study on classification of sleep stage based on EEG signals using feature selection and classification algorithms Journal of Medical Systems	5.200	Q2	2014	181
7	Can YS, Arnrich B, Ersoy C Stress detection in daily life scenarios using smartphones and wearable sensors: A survey Journal of Biomedical Informatics	6.900	Q2	2019	174
8	Ozcift A, Gulten A Classifier ensemble construction with rotation forest to improve medical diagnosis performance of machine learning algorithms Computer Methods and Programs in Biomedicine	6.100	Q1	2011	161
9	Turkyilmazoglu M Single phase nanofluids in fluid mechanics and their hydrodynamic linear stability analysis Computer Methods and Programs in Biomedicine	6.100	Q1	2020	160
10	Kutlu Y, Kuntalp D Feature extraction for ECG heartbeats using higher order statistics of WPD coefficients Computer Methods and Programs in Biomedicine	6.100	Q1	2012	152
11	Dokur Z, Olmez T ECG beat classification by a novel hybrid neural network Computer Methods and Programs in Biomedicine	6.100	Q1	2001	152
12	Cinsdikici MG, Aydin D Detection of blood vessels in ophthalmoscope images using MF/ant (matched filter/ant colony) algorithm Computer Methods and Programs in Biomedicine	6.100	Q1	2009	143
13	Guvenir HA, Demiroz G, Ilter N Learning differential diagnosis of erythemato-squamous diseases using voting feature intervals Artificial Intelligence in Medicine	7.400	Q1	1998	139
14	Deniz E, Sengur A, Kadiroglu Z, Guo Y, Bajaj V, Budak U Transfer learning-based histopathologic image classification for breast cancer detection Health Information Science and Systems	5.700	Q2	2018	133
15	Hariharan M, Polat K, Sindhu R A new hybrid intelligent system for accurate detection of Parkinson's disease Computer Methods and Programs in Biomedicine	6.100	Q1	2014	132

41.87%), health care sciences services (*f*:379, 41.54%), and engineering biomedical (*f*:341, 37.68%). As observed, research has been conducted in various domains ranging from technical fields such as materials science, computer science, information science, and artificial intelligence to applied and practical fields including nursing, health policy services, library science, and psychiatry (Table 6).

The most prominent analysis methods and techniques in the research associated with the research area of computer science interdisciplinary applications are listed as follows: Machine learning, deep learning, neural network, learning algorithms, decision support, feature selection, automatic segmentation, computer simulation, cell segmentation, classification algorithms, random forest (30-47).

In these studies, blood pressure, Doppler signals, artery Doppler, imaging (medical, histopathological, ECG, MRI), care results, human resources management (HRM) data, and surface electromyography (sEMG) signals have been the data or data types analyzed in research and examined for health studies. In computer science interdisciplinary applications research area, considered medical conditions include Parkinson's disease, brain tumor, breast cancer, Alzheimer's disease, cancer diagnosis, colorectal, and glaucoma disease (31,32,35,37,41,48-55). Cancer has emerged as an intensively studied disease in the field of medical informatics.

The research field of engineering biomedical has emerged as another closely related domain to the field of medical informatics. In the engineering biomedical research area, methods and techniques such as neural networks, clustering, segmentation, feature extraction, classification, learning algorithms, machine learning, and deep learning have been extensively utilized, similar to their intensive use in the Computer Science Interdisciplinary Applications field.

In the field of Health Care Sciences Services, the following topics have been prominently featured and extensively studied: EEG signals classification, detection of diseases by processing clinical data, medical decision support systems, classification methods for different purposes, attitudes of health professionals, some software tools and programmable tools, social media use for health topics (15,56-61). Intensively conducted studies in this research area have predominantly focused on disease detection and prediction.

Although it is not among the top three, it is the focal point of medical informatics articles related to the field of nursing, where there is an intense scientific productivity in the relevant field, the focus is not limited to the development of information systems or software but also on measuring the impact or experience of the developed applications on users. Some prominent topics include the effect of problematic internet use, social appearance anxiety, and social media use, web-based education for students, nurses' attitudes toward computers and computer use, nursing students' mobile technology use, and decision support systems (62-67).

DISCUSSION

A noteworthy aspect of bilateral collaboration is the diaspora effect in international collaboration, i.e., the Turkish diaspora in the scientific world plays a crucial role in the internationalization of Turkish researchers. When the names of researchers are carefully analyzed, it is observed that our citizens who worked at prestigious international institutions have successfully conducted rigorous research in these countries, and then they have continued their collaborations with researchers in these prestigious institutions upon returning to Turkey. This is a very important and valuable finding highlighting the importance of doing graduate studies abroad or increasing support for sending Turkish researchers abroad for postdoctoral research to achieve better results in research

Table 6. The other areas related to medical informatics research fields located in Turkey

Rank	Web of Science Categories	n	% of 905
	Medical Informatics	905	100
1	Computer Science Interdisciplinary Applications	379	41.87
2	Health Care Sciences Services	376	41.54
3	Engineering Biomedical	341	37.68
4	Computer Science Theory Methods	162	17.90
5	Mathematical Computational Biology	160	17.68
6	Computer Science Information Systems	93	10.27
7	Public Environmental Occupational Health	39	4.30
8	Nursing	36	3.97
9	Computer Science Artificial Intelligence	32	3.53
10	Medicine General Internal	30	3.31
11	Health Policy Services	22	2.43
12	Statistics Probability	13	1.43
13	Medicine Research Experimental	8	0.88
14	Information Science Library Science	7	0.77
15	Pharmacology Pharmacy	3	0.33
16	Computer Science Cybernetics	1	0.11
17	Computer Science Software Engineering	1	0.11
18	Materials Science Biomaterials	1	0.11
19	Medical Laboratory Technology	1	0.11
20	Psychiatry	1	0.11
21	Psychology Clinical	1	0.11

outcomes and improve Turkey's scientific standing in medical informatics. If our researchers abroad want to stay, their stay should be supported given a good plan for further network and capacity building, and positive support can be provided for them to maintain their ties with Turkey.

It is also important to highlight the frequent collaboration between Middle East Technical University and Hacettepe University, which has an internationally well-known faculty of medicine. This may imply that highly technical institutions may rely on their strong methodological backgrounds to develop or utilize advanced methods of analyzing medical data from their collaborating institutions to conduct high-quality medical informatics research. This could be an ideal approach for promoting medical informatics research in Turkish institutions without medical schools, for which proper incentives can be introduced by funding agencies and scientific regulation offices. In addition, this study shows that 68.61% of the health studies addressed in Turkey were not supported. It can be said that this value is quite low for a research field such as medical informatics, which has direct links with two critical and current fields such as health and information sciences.

Bradford's Law of Distribution defines the distribution of articles or publications on a specific topic across journals. Garfield characterized Bradford's Law as follows: "If you want to compile a bibliography on a specific subject, you will find that a small core group of journals contains about one-third of the articles published in that subject or discipline, which we always refer to as the significant core." (29). From this perspective, the core journals for researchers in the field of medical informatics in Turkey can be identified as the Journal of Medical Systems and Computer Methods and Programs in Biomedicine.

The homogeneous relationship of the articles in the field of medical informatics produced in Turkey with computer science, statistics, health sciences, and even materials science and psychiatry research fields can be considered as strong evidence of the multidisciplinary nature of the field. This can be illustrated by an analysis of keywords in the considered studies. The distribution of keywords used by researchers in their studies includes machine learning (*f*:62), deep learning (*f*:48), classification (*f*:38), COVID-19 (*f*:23), feature extraction (*f*:23), electroencephalography (EEG, *f*:22), Turkey (*f*:19), feature selection (*f*:17), artificial intelligence (*f*:15), data mining (*f*:15), artificial neural networks (*f*:13), convolutional neural networks (*f*:12), image processing (*f*:12), neural networks (*f*:12), transfer learning (*f*:12), support vector machines (*f*:11), fuzzy logic (*f*:10), and image segmentation (*f*:10). It is observed that the keywords used in the considered articles have a significant influence from computer and decision sciences. The need for the systematic processing of data, information, and knowledge in medicine and health services continues. Moreover, due to its cross-sectional nature covering most disciplines in medicine and health sciences, medical Informatics should be considered a critical field for the future of medicine and health services.

When the abstracts of the studies are examined according to the trend topic analysis, the situation depicted in Figure 3 emerges. It is evident here that technological transformation is directly reflected in the literature. While smart card technology was intensively used in the 2000s, in recent years, virtual reality (21,68) stands out in health informatics studies affiliated with Turkey. As seen in Figure 3a and Figure 3b, the topic headings of neural networks, decision support, decision science, machine learning, and deep learning have maintained their significance in research affiliated with Turkey throughout the years. While COVID-19 studies intensified during the period of 2017-2021, in recent years, the efforts have shifted more toward the healthcare domain (68,69).

CONCLUSION

Our study comprehensively evaluated original and review articles in the field of medical informatics from 1980 to the present using bibliometric methods, focusing on country-, researcher-, institution-, and citation-, and keyword-specific measures and patterns. It was observed that international collaboration in medical informatics research with Turkish affiliation is quite low. Researchers were found to collaborate with their colleagues in prestigious institutions abroad mainly in countries such as the USA, England, Germany, and France. The research, for the most part, revolves around specific universities, with researchers making personal efforts and aligning with prominent figures in the field. Furthermore, the scientific productivity of institutions in the field of medical informatics located in Turkey has been observed to be notably low. Organizing conferences indexed in the CPCI-S would be highly beneficial for these institutions to achieve better standings in international ranking systems. It is recommended that TUBİTAK particularly encourages and supports such conferences. Additionally, it is believed that the establishment of a journal associated with medical informatics research in Turkey, indexed in the SCIE, would positively contribute to the advancement of the field.

Enhancing the scope and quality of education in health and medical informatics will contribute to improving the quality and efficiency of healthcare services in Turkey in the long run. Although the study was conducted in Turkey, it can be argued that the developments in medical informatics research exhibit similarities for all countries, given the universal nature of science. The current and emerging research topics in medical informatics research are expected to influence the curriculum of medical informatics programs in different countries. Particularly, topics like artificial intelligence and machine learning are crucial for healthcare professionals and have been extensively covered in the literature. These subjects have become integral to processes in healthcare services in recent years. Therefore, it is strongly recommended for policymakers to promptly add at least one or two courses related to these topics in the curriculums.

Although our study primarily delves into the broader research landscape within the field of medical informatics in Turkey, it is posited that these overarching trends are likely to align with global patterns. This alignment is attributed to the fact that advancements in scientific research are frequently influenced by contemporary issues. Consequently, the discussions and recommendations presented in this study hold potential utility for researchers across the entire spectrum of medical informatics, particularly those situated in upper-middle and mid-income countries currently engaged in refining their research landscapes.

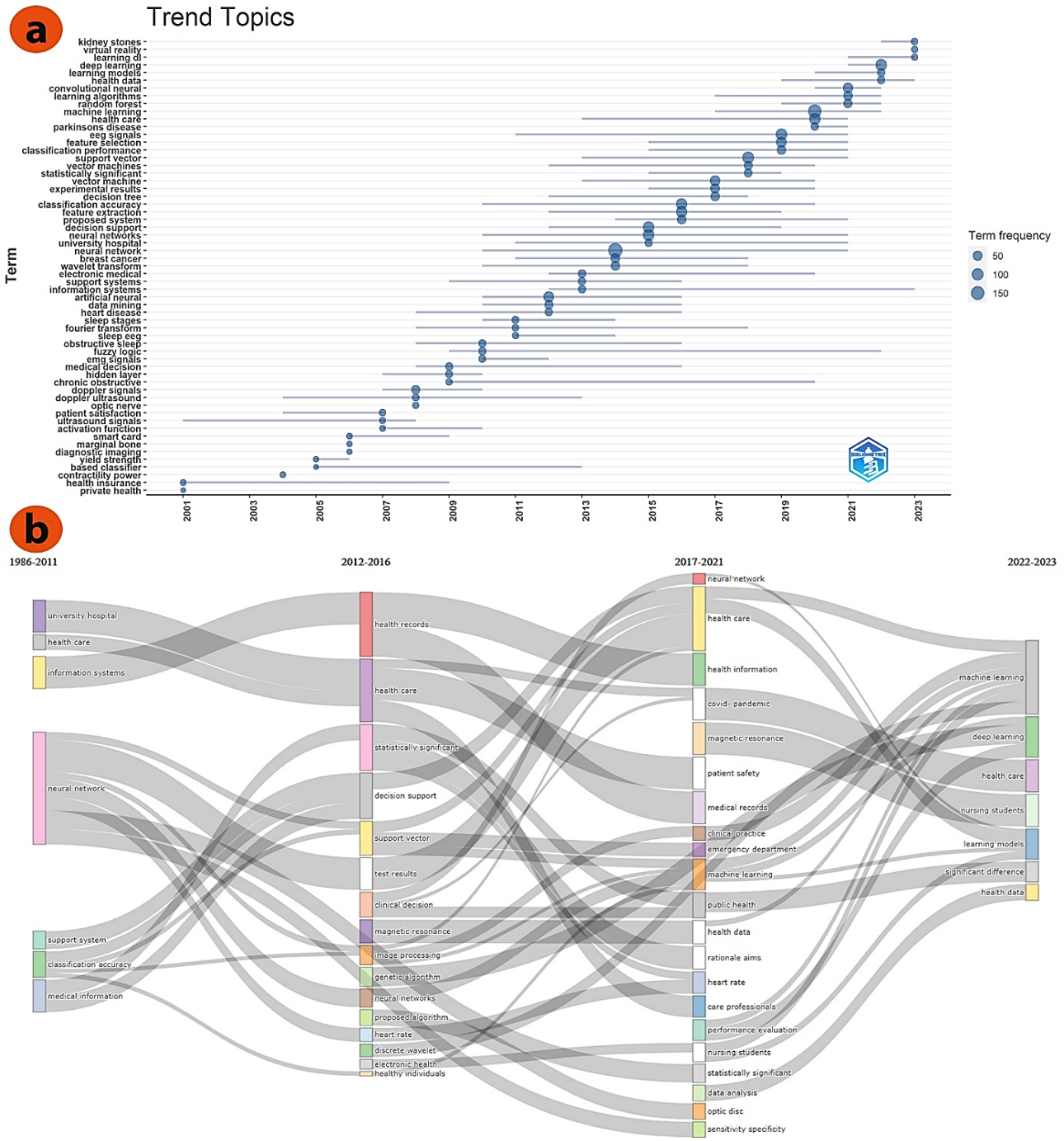

Figure 3. Research words features according to abstract used in the trend topic analysis (a) and thematic evaluation (b)

Ethics Committee Approval: Since our study was not an experimental study including human or animal subject, ethics committee approval was not required.

Conflict of Interest: None declared by the authors.

Financial Disclosure: None declared by the authors.

Acknowledgments: None declared by the authors.

Author Contributions: Idea/Concept: MD; Design: MD, TK, İY, AEÇ, JKP, FSE; Data Collection/Processing: MD, TK, İY, AEÇ; Analysis/Interpretation: MD, TK, İY, AEÇ, FSE; Literature Review: MD, TK, İY, AEÇ; Drafting/ Writing: MD, TK, JKP, FSE; Critical Review: MD, JKP, FSE.

REFERENCES

1. Atilla EA, Seyhan F. An academic examination of the development of health informatics in Turkey. SDU Visionary Journal. 2022;13(34):364-81. Turkish.
2. Masic I. The history of medical informatics development - an overview. Int J Biomed Healthc. 2020;8(1):37-52.
3. Wyatt JC, Liu JL. Basic concepts in medical informatics. J Epidemiol Community Health. 2002;56(11):808-12.
4. Lincoln TL. Medical informatics: the substantive discipline behind health care computer systems. Int J Biomed Comput. 1990;26(1-2):73-92.
5. Haux R. Health and medical informatics education: perspectives for the next decade. Int J Med Inform. 1998;50(1-3):7-19.

6. Haux R. Medical informatics: past, present, future. Int J Med Inform. 2010;79(9):599-610.
7. van Bemmel JH, Duisterhout JS. Education and training of medical informatics in the medical curriculum. Int J Med Inform. 1998;50(1-3):49-58.
8. Masic I, Pandza, H. Medical informatics education - past, today and future. Eur J Biomed Inform. 2018;14(2):40-45.
9. Kuzeci E. eHealth and new legal problems. InU Law Review. 2018;9(1):477-506. Turkish.
10. Mutluay E, Ozdemir, L. Use of nursing informatics within the scope of health information systems. Florence Nightingale J Nurs 2014;22(3):180-6. Turkish.
11. Ozata M. Importance of health information systems increasing of hospital efficiency: an application used data envelopment analysis. Journal of Productivity. 2009;4:37-51. Turkish.
12. Peker M. A decision support system to improve medical diagnosis using a combination of k-medoids clustering based attribute weighting and SVM. J Med Syst. 2016;40(5):116.
13. Sengul Y. Health informatics infrastructure development of the public space and e-health services in Turkey. J Health Soc Welf Res. 2019;1(2):14-20. Turkish.
14. Yucel YB, Aytekin A, Ayaz A, Tumincin F. The importance of health sectors of information systems. Eurasian J Res Soc Econ. 2018;5(8):147-55. Turkish.
15. Armfield NR, Edirippulige S, Caffery LJ, Bradford NK, Grey JW, Smith AC. Telemedicine--a bibliometric and content analysis of 17,932 publication records. Int J Med Inform. 2014;83(10):715-25.
16. Chen X, Xie H, Wang FL, Liu Z, Xu J, Hao T. A bibliometric analysis of natural language processing in medical research. BMC Med Inform Decis Mak. 2018;18(Suppl 1):14.
17. Eckert M, Volmerg JS, Friedrich CM. Augmented reality in medicine: systematic and bibliographic review. JMIR Mhealth Uhealth. 2019;7(4):e10967.
18. Guo Y, Hao Z, Zhao S, Gong J, Yang F. Artificial intelligence in health care: bibliometric analysis. J Med Internet Res. 2020;22(7):e18228.
19. Hsu YH, Ho YS. Highly cited articles in health care sciences and services field in Science Citation Index Expanded. A bibliometric analysis for 1958 - 2012. Methods Inf Med. 2014;53(6):446-58.
20. Kim J, Lee D, Park E. Machine learning for mental health in social media: bibliometric study. J Med Internet Res. 2021;23(3):e24870.
21. Pawassar CM, Tiberius V. Virtual reality in health care: bibliometric analysis. JMIR Serious Games. 2021;9(4):e32721.
22. Shaikh AK, Alhashmi SM, Khalique N, Khedr AM, Raahemifar K, Bukhari S. Bibliometric analysis on the adoption of artificial intelligence applications in the e-health sector. Digit Health. 2023;9:20552076221149296.
23. Sweileh WM, Al-Jabi SW, AbuTaha AS, Zyoud SH, Anayah FMA, Sawalha AF. Bibliometric analysis of worldwide scientific literature in mobile - health: 2006-2016. BMC Med Inform Decis Mak. 2017;17(1):72.
24. Tang R, Zhang S, Ding C, Zhu M, Gao Y. Artificial intelligence in intensive care medicine: bibliometric analysis. J Med Internet Res. 2022;24(11):e42185.
25. Yang YT, Iqbal U, Ching JH, Ting JB, Chiu HT, Tamashiro H, Hsu YH. Trends in the growth of literature of telemedicine: A bibliometric analysis. Comput Methods Programs Biomed. 2015;122(3):471-9.
26. Al U, Sezen U, Soydal I. The evaluation of scientific publications of Hacettepe University using social network analysis method. HU J Fac Lett. 2012;29(1):53-71. Turkish.
27. Bilik O, Turhan Damar HT, Ozdagoglu G, Ozdagoglu A, Damar M. Identifying trends, patterns, and collaborations in nursing career research: A bibliometric snapshot (1980-2017). Collegian. 2020;27(1):40-8.
28. Abafe EA, Bahta YT, Jordaan H. Exploring biblioshiny for historical assessment of global research on sustainable use of water in agriculture. Sustainability. 2022;14(17):10651.
29. Garfield E. Bradford's law and related statistical patterns. Essays. 1980;4(19):476-83.
30. Akal F, Batu ED, Sonmez HE, Karadag SG, Demir F, Ayaz NA, et al. Diagnosing growing pains in children by using machine learning: a cross-sectional multicenter study. Med Biol Eng Comput. 2022;60(12):3601-14.
31. Mikhailova V, Anbarjafari G. Comparative analysis of classification algorithms on the breast cancer recurrence using machine learning. Med Biol Eng Comput. 2022;60(9):2589-600.
32. Karapinar Senturk Z. Layer recurrent neural network-based diagnosis of Parkinson's disease using voice features. Biomed Tech (Berl). 2022;67(4):249-66.
33. Durak S, Bayram B, Bakirman T, Erkut M, Dogan M, Gurturk M, et al. Deep neural network approaches for detecting gastric polyps in endoscopic images. Med Biol Eng Comput. 2021;59(7-8):1563-74.
34. Hatipoglu N, Bilgin G. Cell segmentation in histopathological images with deep learning algorithms by utilizing spatial relationships. Med Biol Eng Comput. 2017;55(10):1829-48.
35. Ibrahim MH, Hacibeyoglu M, Agaoglu A, Ucar F. Glaucoma disease diagnosis with an artificial algae-based deep learning algorithm. Med Biol Eng Comput. 2022;60(3):785-96.
36. Polat H, Aluçlu MU, Ozerdem MS. Evaluation of potential auras in generalized epilepsy from EEG signals using deep convolutional neural networks and time-frequency representation. Biomed Tech (Berl). 2020;65(4):379-91.
37. Cengiz E, Kelek MM, Oguz Y, Yilmaz C. Classification of breast cancer with deep learning from noisy images using wavelet transform. Biomed Tech (Berl). 2022;67(2):143-50.
38. Ileri R, Latifoglu F, Demirci E. A novel approach for detection of dyslexia using convolutional neural network with EOG signals. Med Biol Eng Comput. 2022;60(11):3041-55.
39. Kuru K, Niranjan M, Tunca Y, Osvank E, Azim T. Biomedical visual data analysis to build an intelligent diagnostic decision support system in medical genetics. Artif Intell Med. 2014;62(2):105-18.
40. Dag O, Kasikci M, Ilk O, Yesiltepe M. GeneSelectML: a comprehensive way of gene selection for RNA-Seq data via machine learning algorithms. Med Biol Eng Comput. 2023;61(1):229-41.

41. Hariharan M, Polat K, Sindhu R. A new hybrid intelligent system for accurate detection of Parkinson's disease. Comput Methods Programs Biomed. 2014;113(3):904-13.
42. Köse C, Sevik U, Ikibas C, Erdol H. Simple methods for segmentation and measurement of diabetic retinopathy lesions in retinal fundus images. Comput Methods Programs Biomed. 2012;107(2):274-93.
43. Doruk RO. Feedback controlled electrical nerve stimulation: a computer simulation. Comput Methods Programs Biomed. 2010;99(1):98-112.
44. Yılmaz B, Ciftci E. An FDTD-based computer simulation platform for shock wave propagation in electrohydraulic lithotripsy. Comput Methods Programs Biomed. 2013;110(3):389-98.
45. Albayrak A, Bilgin G. Automatic cell segmentation in histopathological images via two-staged superpixel-based algorithms. Med Biol Eng Comput. 2019;57(3):653-65.
46. Akkoc B, Arslan A, Kok H. Automatic gender determination from 3D digital maxillary tooth plaster models based on the random forest algorithm and discrete cosine transform. Comput Methods Programs Biomed. 2017;143:59-65.
47. Ozkan IA, Koklu M, Sert IU. Diagnosis of urinary tract infection based on artificial intelligence methods. Comput Methods Programs Biomed. 2018;166:51-9.
48. Bayrak T, Cetin Z, Saygili EI, Ogul H. Identifying the tumor location-associated candidate genes in development of new drugs for colorectal cancer using machine-learning-based approach. Med Biol Eng Comput. 2022;60(10):2877-97.
49. Beheshti I, Demirel H, Farokhian F, Yang C, Matsuda H; Alzheimer's Disease Neuroimaging Initiative. Structural MRI-based detection of Alzheimer's disease using feature ranking and classification error. Comput Methods Programs Biomed. 2016;137:177-93.
50. Ozbay E, Altunbey Ozbay F. Interpretable features fusion with precision MRI images deep hashing for brain tumor detection. Comput Methods Programs Biomed. 2023;231:107387.
51. Sailunaz K, Alhajj S, Ozyer T, Rokne J, Alhajj R. A survey on brain tumor image analysis. Med Biol Eng Comput. 2024;62(1):1-45.
52. Suner A, Celikoglu CC, Dicle O, Sokmen S. Sequential decision tree using the analytic hierarchy process for decision support in rectal cancer. Artif Intell Med. 2012;56(1):59-68.
53. Tunc HC, Sakar CO, Apaydin H, Serbes G, Gunduz A, Tutuncu M, et al. Estimation of Parkinson's disease severity using speech features and extreme gradient boosting. Med Biol Eng Comput. 2020;58(11):2757-73.
54. Turhan G, Kucuk H, Isik EO. Spatio-temporal convolution for classification of Alzheimer disease and mild cognitive impairment. Comput Methods Programs Biomed. 2022;221:106825.
55. Yengec-Tasdemir SB, Aydin Z, Akay E, Dogan S, Yilmaz B. Improved classification of colorectal polyps on histopathological images with ensemble learning and stain normalization. Comput Methods Programs Biomed. 2023;232:107441.
56. Akgundogdu A, Jennane R, Aufort G, Benhamou CL, Ucan ON. 3D image analysis and artificial intelligence for bone disease classification. J Med Syst. 2010;34(5):815-28.
57. Aslan K, Bozdemir H, Sahin C, Ogulata SN, Erol R. A radial basis function neural network model for classification of epilepsy using EEG signals. J Med Syst. 2008;32(5):403-8.
58. Ay B, Yildirim O, Talo M, Baloglu UB, Aydin G, Puthankattil SD, et al. Automated depression detection using deep representation and sequence learning with EEG signals. J Med Syst. 2019;43(7):205.
59. Barlas T, Ecem Avci D, Cinici B, Ozkilicaslan H, Muhittin Yalcin M, Eroglu Altinova A. The quality and reliability analysis of YouTube videos about insulin resistance. Int J Med Inform. 2023;170:104960.
60. Beyan OD, Baykal N. A knowledge based search tool for performance measures in health care systems. J Med Syst. 2012;36(1):201-21.
61. Bozkurt S, Zayim N, Gulkesen KH, Samur MK, Karaagaoglu N, Saka O. Usability of a web-based personal nutrition management tool. Inform Health Soc Care. 2011;36(4):190-205.
62. Avdal EU, Kizilci S, Demirel N. The effects of web-based diabetes education on diabetes care results: a randomized control study. Comput Inform Nurs. 2011;29(2):101-6.
63. Ocak H. A medical decision support system based on support vector machines and the genetic algorithm for the evaluation of fetal well-being. J Med Syst. 2013;37(2):9913.
64. Ayar D, Ozalp Gerceker G, Ozdemir EZ, Bektas M. The effect of problematic internet use, social appearance anxiety, and social media use on nursing students' nomophobia levels. Comput Inform Nurs. 2018;36(12):589-95.
65. Ilaslan E, Ozer Z. Web-based training and telephone follow-up of patients with heart failure: randomized controlled trial. Comput Inform Nurs. 2021;40(2):82-9.
66. Kaya N. Factors affecting nurses' attitudes toward computers in healthcare. Comput Inform Nurs. 2011;29(2):121-9.
67. Turan N, Kaya H, Durgun H, Asti T. Nursing students' technological equipment usage and individual innovation levels. Comput Inform Nurs. 2019;37(6):298-305.
68. Aksoy E. Comparing the effects on learning outcomes of tablet-based and virtual reality-based serious gaming modules for basic life support training: randomized trial. JMIR Serious Games. 2019;7(2):e13442.
69. Kisa A. The Turkish commercial health insurance industry. J Med Syst. 2001;25(4):233-9.