Adoption and implementation of electronic healthcare management system – a bibliometric approach

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Abstract: Electronic healthcare management system (EHMS) is seen to have a positive impact on healthcare, but its implementation and adoption are still very low; also, research results on its influence are limited. To ascertain the cause for this gap, a study was conducted to identify gaps in research and knowledge regarding EHMS adoption. This study sought to quantify this lack of research by identifying the current state of EHMS globally and determines how research

on implementation, influence, and adoption of EHMS has evolved; two databases were searched for literatures in EHMS, and a bibliometric analysis was performed to understand the nature of research and publication trends in EHMS. We found a relatively small number of literatures that focused on EHMS and a declining state of publication. This study highlights the need to develop a strong evidence base research to support the influence, adoption and effective implementation of EHMS in healthcare institutions.

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1   Introduction

eHealth – the use of information technology for healthcare, is a young and dynamic field that could improve the well-being of people around the world, most notably in Africa and Oceania. Electronic healthcare management system (EHMS) is the application of information technology for health care management. It includes all activities that apply information and communication technology (ICT) to promote healthcare services support, delivery, and education for improving efficiency in health care delivery to the citizens (Adebayo and Ofoegbu, 2014).

Electronics healthcare management system can either be patient care focused, for example, keeping healthcare record for patient care purposes or focused on the administration of healthcare practices. Electronics healthcare management system holds relevant healthcare data that can be used in different healthcare scenarios based on needs. Electronics healthcare management system is an integrated system that can be used in multiple ways in carrying out quality healthcare services for patients, e.g., monitoring of patient's medication and usage over a period of time, significant reduction of paper-based communication of health record and documentation filling through electronic health record (EHRs). The use of EHMS has provided a lot of clinical advantages ranging from the elimination of paper records, easy access to healthcare data, smooth interaction, and collaboration with affiliated healthcare organisations. The emergence and adoption of EHMS into the healthcare sector is on the rise, and it will likely transform the way care is delivered, reduce the cost incurred for healthcare services, and improve the quality of healthcare services provided (Salehahmadi and Hajialiasghari, 2013).

Healthcare institutions around the world, including hospitals, clinics, laboratories and pharmacies, are gradually adopting the use of EHMS into their daily healthcare practices (Evans, 2016). The implementation of electronic health record (EHRs), which is a critical component of EHMS into healthcare institutions, will play a vital role in ensuring healthcare data is collected, stored, and readily available when needed, which will, in turn improve care delivery globally.

Even though EHMS is seen to have positive impact on healthcare, its implementation and adoption is still very low; the technologies have been adopted very slowly by healthcare providers and physicians due to many reasons including the cost of implementation, issues around the usability and support of the new system by healthcare professionals (Ajami and Bagheri-Tadi, 2013). Furthermore, research results and relevant information on the implementation, influence, and adoption of EHMS is limited. In order to ascertain the root cause for this gap, we conducted a study to identify gaps in research and knowledge regarding EHMS adoption and implementation. As part of our study, we

conduct a comprehensive search of two databases, Web of Science and Scopus, for literature in EHMS. Subsequently, we then embarked on a bibliometric analysis of these kinds of literature to understand the nature of research and publication trends in EHMS globally, taking into consideration some bibliometrics indicators to provide clarity and a different perspective into our study.

Our research will focus on providing answers to the following questions:

1   What is the current state of EHMS globally?

2   How has research on implementation, influence, and adoption of EHMS evolved?

3   What are the landmark research results and publications in EHMS are?

4   What contributions have these EHMS publications had over time?

5   Who has been the most productive and high impact researcher in EHMS?

The rest of the paper is organised as follows; Section 2 discuss in detail our research methodology; Section 3 reviews the bibliometric methods we utilised in this paper. Section 4 presents the results, including the publication and citation trend on EHMS, leading authors, institutions, countries, leading continents, and sources in EHMS research. Section 5 develops a graphical analysis of the bibliographic data of EHMS with VOS viewer software. Section 6 summarises the main findings and concludes the paper.

2   Research methodology

In our research, we have used a bibliometric approach to review existing papers in EHMS, following several steps as identified by researchers in Clarke and Horton (2001) and Tranfield et al. (2003). These steps include planning the review, selecting and reviewing the papers, synthesising the results, and reporting the findings (Pérez-Jover et al., 2019).

In planning our literature review, we conducted a comprehensive literature search on two electronic databases: Web of Science and Scopus. We then ranked and grouped the papers for review.

To facilitate the search, we used the following criteria:

1   topic: electronic healthcare management system

2   publication year: 2008–2018

3   document types: articles.

Publications of interest were those published in English and with information on EHMS. Exclusion criteria were studies that were not published in English as well as those that were not related to e-health. We have followed the flowchart below in selecting and reviewing the papers to be included in our study, it explains in detail our methodology from identifying the literature in the two databases to how we arrived at our final selection.

Figure 1 Flow diagram of inclusion and exclusion (see online version for colours)
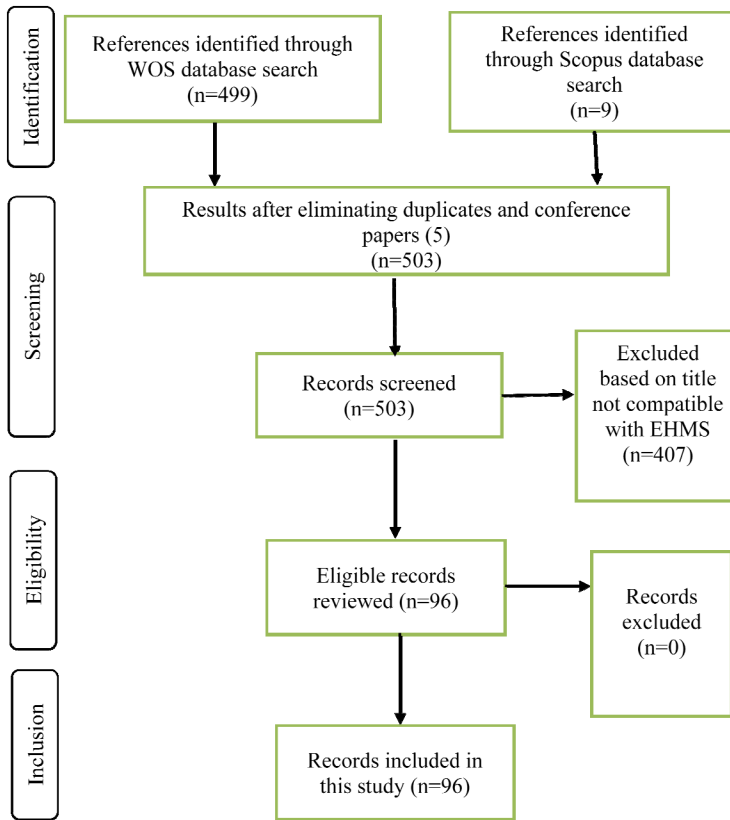
Source: Pérez-Jover et al. (2019)

3 Applied bibliometric methods in electronic healthcare management system

Bibliometrics is a research area which applies statistical analysis to bibliometric data to provide understanding, identify patterns or analyse a particular section of literature, and this could include publication in a particular area, authorship, citation (Welsh, 2017; Broadus, 1987; Pritchard, 1969).

Different researchers have categorised bibliometric research in different ways, researchers in Borgman (1989) categorised bibliometrics into three types, which include analysis of the producers, e.g., author, institution; analysis of artefacts, e.g., journals, book chapters, websites; and the analysis of concept e.g., topics or subject areas.

Stevens (1953) took a different approach and categorised bibliometrics into two types, which are descriptive and evaluative. The descriptive approach could take into consideration the productivity of the author, institution, and geographical area while evaluative considers the usage data, citation trend, and h-index.

Nicholas and Ritchie (1978) used two related categories; these include literature characteristics (authorship, year of publication) and literature relationships (citations or

patterns for co-citing). Another researcher who has categorised differently or develop models to categorise bibliometric research.

In this study, we have taken into consideration most of these indicators to provide clarity and different perspectives to understand our results. Research mainly can be evaluated by productivity and influence (Podsakoff et al., 2008), number of publications in a research area could be used to measure productivity while influence could be measured using the number of citations. In addition to these two indicators, we also considered other bibliometric indicators in our paper including the cites per paper, the cites per year, types of outlets, yearly citation trend, most productive institutions, countries and geographical regions (continents), which was analysed using the number of papers and citations per million inhabitants.

Additionally, our study uses VOSviewer software (van Eck and Waltman, 2009) to graphically map the bibliographic data. VOSviewer is a tool used to analyse bibliometric networks. It works by building maps of authors, publications based on citations, co-citations, co-authorship, co-occurrence of author keywords. All these are key indicators used in analysing our results. Citation analysis is used to identifies how the documents cite each other counting the number of times that article A cites article B and vice versa. When the same third source cites two documents, this is referred to co-citation (Small, 1973).

Co-authorship shows the connections in documents that are co-authored by more than one author, institution or country and lastly, co-occurrence of author keywords identifies the most frequent keywords used by the authors and those keywords that appear more frequently in the same documents.

4   Results

We downloaded information about nine articles from Scopus and 499 papers from Web of Science (total 508) that were available by June 2019. The information about the search results from the electronic databases were organised for independent evaluation by our researchers. After performing a critical review of our search results; for example, we eliminated duplicate, performed exclusion based on paper titles not compatible with EHMS and reviewed the publication abstracts, we then arrived at a total of 96 publications to be included in our analysis (91 Web of Science and 5 Scopus papers). We have used the combination of descriptive and evaluative bibliometric approach in carrying out our analysis, which took into consideration productivity of the authors, institution, and geographical area, citation trend etc.; we also used literature relationships including citations and patterns for co-citing as a key indicator to provide clarity to our results.

4.1   Publication and citation trends

Table 1 presents the most cited papers in EHMS in Web of Science and Scopus between 2008 and 2018. During this period, the three most cited papers in Web of Science represent the contribution of Sittig, Dean; Greenhalgh, Trisha and Lluch, Maria; who had 171, 143 and 117 respectively. The first two papers by Sittig, Dean; Greenhalgh, Trisha; which are the most cited in Web of Science on EHMS were both published in year 2010.

Table 1a   The most cited papers in EHMS between 2008–2018 (Web of Science)

Order	Author (s)	Title	Publication year	Total citations	Citation per year
1	Sittig, Dean F.; Singh, Hardeep	A new sociotechnical model for studying health information technology in complex adaptive healthcare systems	2010	171	17.1
2	Greenhalgh, Trisha; Hinder, Susan; et al.	Adoption, non-adoption, and abandonment of a personal electronic health record: case study of HealthSpace	2010	134	13.4
3	Lluch, Maria	Healthcare professionals' organisational barriers to health information technologies – a literature review	2011	117	13
4	de Lusignan, Simon; Mold, Freda; et al.	Patients' online access to their electronic health records and linked online services: a systematic interpretative review	2014	73	12.17
5	Estabrooks, Paul A.; Boyle, Maureen; et al.	Harmonized patient-reported data elements in the electronic health record: supporting meaningful use by primary care action on health behaviors and key psychosocial factors	2012	72	9
6	Mandel, Joshua C.; Kreda, David A.; et al.	SMART on FHIR: a standards-based, interoperable apps platform for electronic health records	2016	57	14.25
7	Kazley, Abby S.; Ozcan, Yasar A.	Do hospitals with electronic medical records (EMRs) provide higher quality care? An examination of three clinical conditions	2008	52	4.33
8	Masys, Daniel R.; Jarvik, Gail P.; et al.	Technical desiderata for the integration of genomic data into electronic health records	2012	51	6.38
9	Peleg, Mor; Keren, Sagi; Denekamp, Yaron	Mapping computerized clinical guidelines to electronic medical records: knowledge-data ontological mapper (KDOM)	2008	51	4.25
10	Terry, Amanda L.; Thorpe, Cathy F.; et al.	Implementing electronic health records – key factors in primary care	2008	49	4.08
11	Wright, Adam; Poon, Eric G.; et al.	Randomized controlled trial of health maintenance reminders provided directly to patients through an electronic PHR	2012	48	6

Table 1a The most cited papers in EHMS between 2008–2018 (Web of Science) (continued)

Order	Author (s)	Title	Publication year	Total citations	Citation per year
12	Stoves, John; Connolly, John; et al.	Electronic consultation as an alternative to hospital referral for patients with chronic kidney disease: a novel application for networked electronic health records to improve the accessibility and efficiency of healthcare	2010	45	4.5
13	Wong, Martin C.S.; Jiang, Johnny Y.; et al.	Health services research in the public healthcare system in Hong Kong: an analysis of over 1 million antihypertensive prescriptions between 2004–2007 as an example of the potential and pitfalls of using routinely collected electronic patient data	2008	45	3.75
14	Freeman, R.; Moore, L.S.P.; et al.	Advances in electronic surveillance for healthcare-associated infections in the 21st Century: a systematic review	2013	43	6.14
15	Rothman, Brian; Leonard, Joan C.; Vigoda, Michael M.	Future of electronic health records: implications for decision support	2012	38	4.75
16	Ng, Kenney; Ghoting, Amol; et al.	PARAMO: a parallel predictive modeling platform for healthcare analytic research using electronic health records	2014	36	6
17	Chen, Yu-Yi; Lu, Jun-Chao; Jan, Jinn-Ke	A secure EHR system based on hybrid clouds	2012	35	4.38
18	Linder, Jeffrey A.; Kaleba, Erin O.; Kmetik, Karen S.	Using electronic health records to measure physician performance for acute conditions in primary care empirical evaluation of the community-acquired pneumonia clinical quality measure set	2009	32	2.91
19	Meeks, Derek W.; Takian, Amirhossein; et al.	Exploring the sociotechnical intersection of patient safety and electronic health record implementation	2014	31	5.17
20	Wright, Adam; Sittig, Dean F.; et al.	Development and evaluation of a comprehensive clinical decision support taxonomy: comparison of front-end tools in commercial and internally developed electronic health record systems	2011	30	3.33

Table 1a   The most cited papers in EHMS between 2008–2018 (Web of Science) (continued)

Order	Author (s)	Title	Publication year	Total citations	Citation per year
21	Hsu, William; Taira, Ricky K.; et al.	Context-based electronic health record: toward patient specific healthcare	2012	29	3.63
22	Morley, Katherine I.; Wallace, Joshua; et al.	Defining disease phenotypes using national linked electronic health records: a case study of atrial fibrillation	2014	28	4.67
23	Mishra, Abhay Nath; Anderson, Catherine; et al.	Electronic health records assimilation and physician identity evolution: an identity theory perspective	2012	27	3.38
24	Harris, Stewart B.; Glazier, Richard H.; et al.	Investigating concordance in diabetes diagnosis between primary care charts (electronic medical records) and health administrative data: a retrospective cohort study	2010	27	2.7
25	Sittig, Dean F.; Wright, Adam; et al.	Comparison of clinical knowledge management capabilities of commercially-available and leading internally-developed electronic health records	2011	26	2.89
26	Cho, InSook; Kim, JeongAh; et al.	Design and implementation of a standards-based interoperable clinical decision support architecture in the context of the Korean HER	2010	25	2.5
27	Pahl, Christina; Zare, Mojtaba; et al.	Role of OpenEHR as an open source solution for the regional modelling of patient data in obstetrics	2015	23	4.6
28	Ancker, Jessica S.; Kern, Lisa M.; et al.	How is the electronic health record being used? Use of EHR data to assess physician-level variability in technology use	2014	23	3.83
29	Saleem, Jason J.; Flanagan, Mindy E.; et al.	The next-generation electronic health record: perspectives of key leaders from the US Department of Veterans Affairs	2013	23	3.29
30	McGinn, Carrie Anna; Gagnon, Marie-Pierre; et al.	Users' perspectives of key factors to implementing electronic health records in Canada: a Delphi study	2012	23	2.88
31	Jarvis, Benjamin; Johnson, Tricia; et al.	Assessing the impact of electronic health records as an enabler of hospital quality and patient satisfaction	2013	22	3.14

Table 1a   The most cited papers in EHMS between 2008–2018 (Web of Science) (continued)

Order	Author (s)	Title	Publication year	Total citations	Citation per year
32	Sassen, Elizabeth J.	Love, hate, or indifference how nurses really feel about the electronic health record system	2009	22	2
33	O'Reilly, Daria; Holbrook, Anne; et al.	Cost-effectiveness of a shared computerized decision support system for diabetes linked to electronic medical records	2012	21	2.63
34	Kumar, Rajiv B.; Goren, Nira D.; et al.	Automated integration of continuous glucose monitor data in the electronic health record using consumer technology	2016	20	5
35	Wang, Hua-Qiong; Li, Jing-Song; et al.	Creating personalised clinical pathways by semantic interoperability with electronic health records	2013	20	2.86
36	Benhamou, P-Y.	Improving diabetes management with electronic health records and patients' health records	2011	20	2.22
37	Prociow, Pawel A.; Crowe, John A.	Towards personalised ambient monitoring of mental health via mobile technologies	2010	20	2
38	Rahimi, Alireza; Liaw, Siaw-Teng; et al.	Validating an ontology-based algorithm to identify patients with type 2 diabetes mellitus in electronic health records	2014	19	3.17
39	Herbek, S.; Eisl, H.A.; et al.	The electronic health record in Austria: a strong network between health care and patients	2012	19	2.38
40	Wright, Adam; McCoy, Allison B.; et al.	Problem list completeness in electronic health records: a multi-site study and assessment of success factors	2015	18	3.6
41	Phansalkar, Shobha; Zachariah, Marianne; et al.	Evaluation of medication alerts in electronic health records for compliance with human factors principles	2014	18	3
42	Kopanitsa, G.; Hildebrand, C.; et al.	Visualization of medical data based on EHR standards	2013	18	2.57
43	Banerjee, Dipanjan; Chung, Sukyung; et al.	Underdiagnosis of Hypertension Using Electronic Health Records	2012	18	2.25
44	Li, Jing-Song; Zhang, Xiao-Guang; et al.	The meaningful use of EMR in Chinese hospitals: a case study on curbing antibiotic abuse	2013	17	2.43

Table 1a   The most cited papers in EHMS between 2008–2018 (Web of Science) (continued)

Order	Author (s)	Title	Publication year	Total citations	Citation per year
45	Menon, Shailaja; Smith, Michael W.; et al.	How context affects electronic health record-based test result follow-up: a mixed-methods evaluation	2014	16	2.67
46	Noblin, Alice; Cortelyou-Ward, Kendall; et al.	EHR implementation in a new clinic: a case study of clinician perceptions	2013	16	2.29
47	Makam, Anil N.; Nguyen, Oanh K.; et al.	Identifying patients with diabetes and the earliest date of diagnosis in real time: an electronic health record case-finding algorithm	2013	15	2.14
48	Zhang, Jianguo; Zhang, Kai; et al.	Grid-based implementation of XDS-I as part of image-enabled EHR for regional healthcare in Shanghai	2011	15	1.67
49	Ancker, Jessica S.; Kern, Lisa M.; et al.	Associations between healthcare quality and use of electronic health record functions in ambulatory care	2015	14	2.8
50	Guo, Rui; Shi, Huixian; et al.	Secure attribute-based signature scheme with multiple authorities for blockchain in electronic health records systems	2018	13	6.5
51	Dagher, Gaby G.; Mohler, Jordan; et al.	Ancile: privacy-preserving framework for access control and interoperability of electronic health records using blockchain technology	2018	12	6
52	Goldstein, David H.; Phelan, Rachel; et al.	Brief review: Adoption of electronic medical records to enhance acute pain management	2014	12	2
53	Teufel, Ronald J., II; Kazley, Abby Swanson; et al.	Hospital electronic medical record use and cost of inpatient pediatric care	2012	12	1.5
54	Li, Jing-Song; Zhang, Xiao-Guang; et al.	Design and development of EMR supporting medical process management	2012	12	1.5
55	Newsham, Alexander C.; Johnston, Colin; et al.	Development of an advanced database for clinical trials integrated with an electronic patient record system	2011	12	1.33
56	Xiao, Liang; Cousins, Grainne; et al.	Developing an electronic health record (EHR) for methadone treatment recording and decision support	2011	12	1.33

Table 1a   The most cited papers in EHMS between 2008–2018 (Web of Science) (continued)

Order	Author (s)	Title	Publication year	Total citations	Citation per year
57	Marimon-Sunol, Santiago; Rovira-Barbera, Maria; et al.	Shared electronic health record in Catalonia, Spain	2010	11	1.1
58	Grant, C.; Ludbrook, G.; et al.	Adverse physiological events under anaesthesia and sedation: a pilot audit of electronic patient records	2008	11	0.92
59	Yadav, Pranjul; Steinbach, Michael; et al.	Mining electronic health records (EHRs): a survey	2018	10	5
60	van Velthoven, Michelle Helena; Mastellos, Nikolaos; et al.	Feasibility of extracting data from electronic medical records for research: an international comparative study	2016	10	2.5
61	Liu, Chung-Feng; Cheng, Tain-Junn	Exploring critical factors influencing physicians' acceptance of mobile electronic medical records based on the dual-factor model: a validation in Taiwan	2015	10	2
62	Shea, Christopher M.; Reiter, Kristin L.; et al.	Stage 1 of the meaningful use incentive program for electronic health records: a study of readiness for change in ambulatory practice settings in one integrated delivery system	2014	10	1.67
63	Kontio, Elina; Airola, Antti; et al.	Predicting patient acuity from electronic patient records	2014	10	1.67
64	Heart, Tsipi; Ben-Assuli, Ofir; Shabtai, Itamar	A review of PHR, EMR and EHR integration: A more personalized healthcare and public health policy	2017	9	3
65	Jawhari, Badeia; Keenan, Louanne; et al.	Barriers and facilitators to Electronic Medical Record (EMR) use in an urban slum	2016	9	2.25
66	Gagnon, Marie-Pierre; Payne-Gagnon, Julie; et al.	Adoption of electronic personal health records in Canada: perceptions of stakeholders	2016	9	2.25
67	McAlearney, Ann Scheck; Hefner, Jennifer L.; et al.	Evidence-based management of ambulatory electronic health record system implementation: An assessment of conceptual support and qualitative evidence	2014	9	1.5

Table 1a   The most cited papers in EHMS between 2008–2018 (Web of Science) (continued)

Order	Author (s)	Title	Publication year	Total citations	Citation per year
68	Tundia, Namita L.; Kelton, Christina M. L.; et al.	The effect of electronic medical record system sophistication on preventive healthcare for women	2013	9	1.29
69	Navarro, Ronald A.; Greene, Denise F.; et al.	Minimizing Disparities in Osteoporosis Care of Minorities with an Electronic Medical Record Care Plan	2011	9	1
70	del Carmen Legaz-Garcia, Maria; Martinez-Costa, Catalina; et al.	A semantic web-based framework for the interoperability and exploitation of clinical models and EHR data	2016	8	2
71	Sajatovic, Martha; Welter, Elisabeth; et al.	Electronic medical record analysis of emergency room visits and hospitalizations in individuals with epilepsy and mental illness comorbidity	2015	8	1.6
72	Park, Sun Young; Chen, Yunan; Rudkin, Scott	Technological and organizational adaptation of EMR implementation in an emergency department	2015	8	1.6
73	Cardoso de Moraes, Joao Luis; de Souza, Wanderley Lopes; et al.	A methodology based on openEHR archetypes and software agents for developing e-health applications reusing legacy systems	2016	7	1.75
74	Teufel, Ronald J., II; Kazley, Abby Swanson; et al.	Electronic medical record adoption in hospitals that care for children	2013	7	1
75	Al Mallah, Amr; Guelpa, Paul; et al.	Integrating genomic-based clinical decision support into electronic health records	2010	7	0.7
76	Kharrazi, Hadi; Gonzalez, Claudia P.; et al.	Forecasting the maturation of electronic health record functions among US hospitals: retrospective analysis and predictive model	2018	6	3
77	Plantier, Morgane; Havet, Nathalie; et al.	Does adoption of electronic health records improve the quality of care management in France? Results from the French e-SI (PREPS-SIPS) study	2017	6	2
78	de Ruiter, Hans-Peter; Liaschenko, Joan; Angus, Jan	Problems with the electronic health record	2016	6	1.5

Table 1a   The most cited papers in EHMS between 2008–2018 (Web of Science) (continued)

Order	Author (s)	Title	Publication year	Total citations	Citation per year
79	Somolinos, Roberto; Munoz, Adolfo; et al.	Service for the pseudonymization of electronic healthcare records based on ISO/EN 13606 for the secondary use of information	2015	6	1.2
80	McCoy, Allison B.; Wright, Adam; Sittig, Dean F.	Cross-vendor evaluation of key user-defined clinical decision support capabilities: a scenario-based assessment of certified electronic health records with guidelines for future development	2015	6	1.2
81	Marceglia, S.; Fontelo, P.; et al.	A standards-based architecture proposal for integrating patient mHealth apps to electronic health record systems	2015	6	1.2
82	Hazlehurst, Brian L.; Lawrence, Jean M.; et al.	Automating assessment of lifestyle counseling in electronic health records	2014	6	1
83	Zaninelli, M.; Campagnoli, A.; et al.	The O3-Vet project: Integration of a standard nomenclature of clinical terms in a veterinary electronic medical record for veterinary hospitals	2012	6	0.75
84	McEwen, Timothy R.; Elder, Nancy C.; Flach, John M.	Creating safety in primary care practice with electronic medical records requires the consideration of system dynamics	2011	6	0.67
85	De Pietro, Carlo; Francetic, Igor	E-health in Switzerland: the laborious adoption of the federal law on electronic health records (EHR) and health information exchange (HIE) networks	2018	5	2.5
86	Wang, Shirley V.; Rogers, James R.; et al.	Use of electronic healthcare records to identify complex patients with atrial fibrillation for targeted intervention	2017	5	1.67
87	Matton, Marie-Pier; Toledano, Baruch; et al.	Electronic medical record in pediatric intensive care: implementation process assessment	2016	5	1.25
88	Kafi, Mohamed Amine; Ben Othman, Jalel; et al.	CCS_WHMS: a congestion control scheme for wearable health management system	2015	5	1

Table 1a   The most cited papers in EHMS between 2008–2018 (Web of Science) (continued)

Order	Author (s)	Title	Publication year	Total citations	Citation per year
89	Petrakaki, Dimitra; Klecun, Ela	Hybridity as a process of technology's 'translation': customizing a national electronic patient record	2015	5	1
90	Fernando, Bernard; Morrison, Zoe; et al.	Approaches to recording drug allergies in electronic health records: qualitative study	2014	5	0.83
91	Poulymenopoulou, M.; Malamateniou, F.; Vassilacopoulos, G.	E-EPR: a workflow-based electronic emergency patient record	2014	5	0.83

Table 1b   The most cited papers in EHMS between 2008–2018 (Scopus)

Order	Author (s)	Title	Publication year	Total citations	Citation per year
1	Chang P.H.	Modeling the management of electronic health records in healthcare information systems	2011	5	0.71
2	Makela K.; Virjo I.; et al.	Management of electronic patient record systems in primary healthcare in a Finnish county.	2010	5	0.63
3	Bar-Lev S.	The politics of healthcare informatics: Knowledge management using an electronic medical record system	2015	4	1.0
4	Asghar M.R., Russello G.	Automating consent management lifecycle for electronic healthcare systems	2015	2	0.5
5	Pascal C.J.; McInerney C.; et al.	The use of knowledge management in healthcare: The implementation of shared care plans in electronic medical record systems at one primary care practice	2013	2	0.33

Table 2a   The most cited documents by EHMS publications (Web of Science)

Order	Year	Abbreviated reference(s)	Type of outlets	Citations
1	2010	Sittig, Dean F.; Singh, Hardeep	A	171
2	2010	Greenhalgh, Trisha; Hinder, Susan; et al.	A	134
3	2011	Lluch, Maria	A	117
4	2014	de Lusignan, Simon; Mold, Freda; et al.	A	73
5	2012	Estabrooks, Paul A.; Boyle, Maureen; et al.	A	72
6	2016	Mandel, Joshua C.; Kreda, David A.; et al.	A	57
7	2008	Kazley, Abby S.; Ozcan, Yasar A.	A	52

Table 2a The most cited documents by EHMS publications (Web of Science) (continued)

Order	Year	Abbreviated reference(s)	Type of outlets	Citations
8	2012	Masys, Daniel R.; Jarvik, Gail P.; et al.	A	51
9	2008	Peleg, Mor; Keren, Sagi; Denekamp, Yaron	A	51
10	2008	Terry, Amanda L.; Thorpe, Cathy F.; et al.	A	49
11	2012	Wright, Adam; Poon, Eric G.; et al.	A	48
12	2010	Stoves, John; Connolly, John; et al.	A	45
13	2008	Wong, Martin C. S.; Jiang, Johnny Y.; et al.	A	45
14	2013	Freeman, R.; Moore, L. S. P.; et al.	A	43
15	2012	Rothman, Brian; Leonard, Joan C.; Vigoda, Michael M.	A	38
16	2014	Ng, Kenney; Ghoting, Amol; et al.	A	36
17	2012	Chen, Yu-Yi; Lu, Jun-Chao; Jan, Jinn-Ke	A	35
18	2009	Linder, Jeffrey A.; Kaleba, Erin O.; Kmetik, Karen S.	A	32
19	2014	Meeks, Derek W.; Takian, Amirhossein; et al.	A	31
20	2011	Wright, Adam; Sittig, Dean F.; et al.	A	30
21	2012	Hsu, William; Taira, Ricky K.; et al.	A	29
22	2014	Morley, Katherine I.; Wallace, Joshua; et al.	A	28
23	2012	Mishra, Abhay Nath; Anderson, Catherine; et al.	A	27
24	2010	Harris, Stewart B.; Glazier, Richard H.; et al.	A	27
25	2011	Sittig, Dean F.; Wright, Adam; et al.	A	26
26	2010	Cho, InSook; Kim, JeongAh; et al.	A	25
27	2015	Pahl, Christina; Zare, Mojtaba; et al.	A	23
28	2014	Ancker, Jessica S.; Kern, Lisa M.; et al.	A	23
29	2013	Saleem, Jason J.; Flanagan, Mindy E.; et al.	A	23
30	2012	McGinn, Carrie Anna; Gagnon, Marie-Pierre; et al.	A	23
31	2013	Jarvis, Benjamin; Johnson, Tricia; et al.	A	22
32	2009	Sassen, Elizabeth J.	A	22
33	2012	O'Reilly, Daria; Holbrook, Anne; et al.	A	21
34	2016	Kumar, Rajiv B.; Goren, Nira D.; et al.	A	20
35	2013	Wang, Hua-Qiong; Li, Jing-Song; et al.	A	20
36	2011	Benhamou, P-Y.	A	20
37	2010	Prociow, Pawel A.; Crowe, John A.	A	20
38	2014	Rahimi, Alireza; Liaw, Siaw-Teng; et al.	A	19
39	2012	Herbek, S.; Eisl, H. A.; et al.	A	19
40	2015	Wright, Adam; McCoy, Allison B.; et al.	A	18
41	2014	Phansalkar, Shobha; Zachariah, Marianne; et al.	A	18
42	2013	Kopanitsa, G.; Hildebrand, C.; et al.	A	18
43	2012	Banerjee, Dipanjan; Chung, Sukyung; et al.	A	18

Table 2a   The most cited documents by EHMS publications (Web of Science) (continued)

Order	Year	Abbreviated reference(s)	Type of outlets	Citations
44	2013	Li, Jing-Song; Zhang, Xiao-Guang; et al.	A	17
45	2014	Menon, Shailaja; Smith, Michael W.; et al.	A	16
46	2013	Noblin, Alice; Cortelyou-Ward, Kendall; et al.	A	16
47	2013	Makam, Anil N.; Nguyen, Oanh K.; et al.	A	15
48	2011	Zhang, Jianguo; Zhang, Kai; et al.	A	15
49	2015	Ancker, Jessica S.; Kern, Lisa M.; et al.	A	14
50	2018	Guo, Rui; Shi, Huixian; et al.	A	13
51	2018	Dagher, Gaby G.; Mohler, Jordan; et al.	A	12
52	2014	Goldstein, David H.; Phelan, Rachel; et al.	A	12
53	2012	Teufel, Ronald J., II; Kazley, Abby Swanson; et al.	A	12
54	2012	Li, Jing-Song; Zhang, Xiao-Guang; et al.	A	12
55	2011	Newsham, Alexander C.; Johnston, Colin; et al.	A	12
56	2011	Xiao, Liang; Cousins, Grainne; et al.	A	12
57	2010	Marimon-Sunol, Santiago; Rovira-Barbera, Maria; et al.	A	11
58	2008	Grant, C.; Ludbrook, G.; et al.	A	11
59	2018	Yadav, Pranjul; Steinbach, Michael; et al.	A	10
60	2016	van Velthoven, Michelle Helena; Mastellos, Nikolaos; et al.	A	10
61	2015	Liu, Chung-Feng; Cheng, Tain-Junn	A	10
62	2014	Shea, Christopher M.; Reiter, Kristin L.; et al.	A	10
63	2014	Kontio, Elina; Airola, Antti; et al.	A	10
64	2017	Heart, Tsipi; Ben-Assuli, Ofir; Shabtai, Itamar	A	9
65	2016	Jawhari, Badeia; Keenan, Louanne; et al.	A	9
66	2016	Gagnon, Marie-Pierre; Payne-Gagnon, Julie; et al.	A	9
67	2014	McAlearney, Ann Scheck; Hefner, Jennifer L.; et al.	A	9
68	2013	Tundia, Namita L.; Kelton, Christina M. L.; et al.,	A	9
69	2011	Navarro, Ronald A.; Greene, Denise F.; et al.	A	9
70	2016	del Carmen Legaz-Garcia, Maria; Martinez-Costa, Catalina; et al.	A	8
71	2015	Sajatovic, Martha; Welter, Elisabeth; et al.	A	8
72	2015	Park, Sun Young; Chen, Yunan; Rudkin, Scott	A	8
73	2016	Cardoso de Moraes, Joao Luis; de Souza, Wanderley Lopes; et al.	A	7
74	2013	Teufel, Ronald J., II; Kazley, Abby Swanson; et al.	A	7
75	2010	Al Mallah, Amr; Guelpa, Paul; et al.	A	7
76	2018	Kharrazi, Hadi; Gonzalez, Claudia P.; et al.	A	6
77	2017	Plantier, Morgane; Havet, Nathalie; et al.	A	6
78	2016	de Ruiter, Hans-Peter; Liaschenko, Joan; Angus, Jan	A	6
79	2015	Somolinos, Roberto; Munoz, Adolfo; et al.	A	6

Table 2a   The most cited documents by EHMS publications (Web of Science) (continued)

Order	Year	Abbreviated reference(s)	Type of outlets	Citations
80	2015	McCoy, Allison B.; Wright, Adam; Sittig, Dean F.	A	6
81	2015	Marceglia, S.; Fontelo, P.; et al.	A	6
82	2014	Hazlehurst, Brian L.; Lawrence, Jean M.; et al.	A	6
83	2012	Zaninelli, M.; Campagnoli, A.; et al.	A	6
84	2011	McEwen, Timothy R.; Elder, Nancy C.; Flach, John M.	A	6
85	2018	De Pietro, Carlo; Francetic, Igor	A	5
86	2017	Wang, Shirley V.; Rogers, James R.; et al.	A	5
87	2016	Matton, Marie-Pier; Toledano, Baruch; et al.	A	5
88	2015	Kafi, Mohamed Amine; Ben Othman, Jalel; et al.	A	5
89	2015	Petrakaki, Dimitra; Klecun, Ela	A	5
90	2014	Fernando, Bernard; Morrison, Zoe; et al.	A	5
91	2014	Poulymenopoulou, M.; Malamateniou, F.; Vassilacopoulos, G.	A	5

Note: *Outlets: A – Article; B – conference proceedings, C – Book chapter.

Table 2b   The most cited documents by EHMS publications (Scopus)

Order	Year	Abbreviated Reference (s)	Type of outlets	Citations
1	2011	Chang, P.H.	B	5
2	2010	Makela, K.; Virjo, I.; et al.	A	5
3	2015	Bar-Lev, S.	A	4
4	2015	Asghar, M.R., Russello, G.	C	2
5	2013	Pascal, C.J.; McInerney, C.; et al.	A	2

Note: Outlets: A – article; B – conference proceedings, C – book chapter.

In Scopus, the contribution of Chang; Makela, Virjo et al; and Bar-Lev represent the most cited papers in EHMS between the period reviewed. Apart from having the most cited paper in Web of Science on EHMS, Sittig, Dean also had a total of two papers included as part of our review. Wright, Adam has 3 papers in the list being the most productive author in EHMS, while Ancker, Jessica; Li, Jing-Song; and Teufel, Ronald have two papers each.

Table 2 arranged our 96 papers from both Web of Science and Scopus in an order starting from the paper that received the most citation to the least, Table 2 also identifies the type of outlets for these papers in EHMS. In Table 3, we looked into the citation structure for EHMS in Web of Science and Scopus, our work analysed the total number of papers published from 2008 to 2018 and reports the total number of citations they have achieved taken into consideration different citation thresholds. Yearly citation trend from Web of Science reveals that 2010 and 2012 had the highest number of citations in EHMS with a total of 8 and 14 papers respectively.

Table 3a   Yearly citation trend of EHMS (Web of Science)

Year	Total paper	Total citation	≥200	≥100	≥50	≥20	≥10	≥5	≥1
2008	5	208	0	0	2	4	5	5	5
2009	2	54	0	0	0	2	2	2	2
2010	8	440	0	2	2	6	7	8	8
2011	9	247	0	1	0	3	7	9	9
2012	14	411	0	0	2	9	13	14	14
2013	10	190	0	0	0	4	8	10	10
2014	15	301	0	0	1	5	11	15	15
2015	11	109	0	0	0	1	4	11	11
2016	9	131	0	0	1	2	3	9	9
2017	3	20	0	0	0	0	0	3	3
2018	5	46	0	0	0	0	3	5	5

Table 3b   Yearly citation trend of EHMS (Scopus)

Year	Total paper	Total citation	≥200	≥100	≥50	≥20	≥10	≥5	≥1
2008	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0
2010	1	5	0	0	0	0	0	1	1
2011	1	5	0	0	0	0	0	1	1
2012	0	0	0	0	0	0	0	0	0
2013	1	2	0	0	0	0	0	0	1
2014	0	0	0	0	0	0	0	0	0
2015	2	6	0	0	0	0	0	0	2
2016	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0

The number of citations and papers in EHMS is declining through time with 2017 seeing the least citations within the period under review. On Scopus, 2015 had the highest number of citations with a total of two papers, followed by 2010 and 2011 who both had five citations each. Our results show that there has been no paper published in EHMS since 2015.

4.2 Leading authors, institutions and countries in EHMS

In identifying the most productive and influential authors, institutions and countries in EHMS, we organised our results based on how many papers they have in EHMS from 2008 to 2018. Note that in the case where there is a tie, we have ranked based on the number of citations.

Table 4a   Authors productivity in EHMS (Web of Science)

Order	AN	Institution	CT	TP	TC	h-index	AC	≥200	≥100	≥50
1	Wright, Adam	Harvard Medical School	USA	3	96	3	33.67	0	0	1
2	Sittig, Dean F.	University of Texas	USA	2	197	2	105	0	1	1
3	Ancker, Jessica S.	Cornell University	USA	2	37	2	19.5	0	0	0
4	Li, Jing-Song	Zhejiang University	China	2	29	2	14.5	0	0	0
5	Teufel, Ronald J., II	Medical University of South Carolina	USA	2	19	2	10.5	0	0	0
6	Greenhalgh, Trisha	London School of Medicine and Dentistry	UK	1	134	1	134	0	1	1
7	Lluch, Maria	London School of Economics and Political Science	UK	1	117	1	117	0	1	1
8	de Lusignan, Simon	University of Surrey	UK	1	73	1	73	0	0	1
9	Estabrooks, Paul A.	Virginia Tech, USA	USA	1	72	1	72	0	0	1
10	Mandel, Joshua C.	Harvard Medical School, Boston, MA, USA	USA	1	57	1	57	0	0	1
11	Kazley, Abby S.	Medical University of South Carolina	USA	1	52	1	52	0	0	1
12	Masys, Daniel R.	University of Washington	USA	1	51	1	51	0	0	1
13	Peleg, Mor	University of Haifa	Israel	1	51	1	51	0	0	1
14	Terry, Amanda L.	The University of Western Ontario	Canada	1	49	1	49	0	0	0
15	Stoves, John	NHS Foundation Trust, UK	UK	1	45	1	45	0	0	0
16	Wong, Martin C. S.	Chinese University of Hong Kong	Hong Kong	1	45	1	45	0	0	0
17	Freeman, R.	Imperial College, London, UK	UK	1	43	1	43	0	0	0
18	Rothman, Brian	Vanderbilt University, USA	USA	1	38	1	38	0	0	0
19	Ng, Kenney	IBM TJ Watson Research Center	USA	1	36	1	36	0	0	0
20	Chen, Yu-Yi	National Chung Hsing University	China	1	35	1	35	0	0	0

Note: Abbreviations: author name – AN; country – CT; total paper – TP; total citation – TC; average citation per item – AC.

Table 4a   Authors productivity in EHMS (Web of Science) (continued)

Order	AN	Institution	CT	TP	TC	h-index	AC	≥200	≥100	≥50
21	Linder, Jeffrey A.	Harvard Medical School	USA	1	32	1	32	0	0	0
22	Meeks, Derek W.	Baylor College of Medicine	USA	1	31	1	31	0	0	0
23	Hsu, William	University of California at Los Angeles	USA	1	29	1	29	0	0	0
24	Morley, Katherine I.	University College London	UK	1	28	1	28	0	0	0
25	Mishra, Abhay Nath	Georgia State University	USA	1	27	1	27	0	0	0
26	Harris, Stewart B.	The University of Western Ontario	Canada	1	27	1	27	0	0	0
27	Cho, InSook	Inha University	South Korea	1	25	1	25	0	0	0
28	Pahl, Christina	Ilmenau University of Technology	Germany	1	23	1	23	0	0	0
29	Saleem, Jason J.	Indiana University	USA	1	23	1	23	0	0	0
30	McGinn, Carrie Anna	Institut de réadaptation en déficience physique de Québec	Canada	1	23	1	23	0	0	0
31	Jarvis, Benjamin	NorthShore University	USA	1	22	1	22	0	0	0
32	Sassen, Elizabeth J.	Loyola University	USA	1	22	1	22	0	0	0
33	O'Reilly, Daria	McMaster University	Canada	1	21	1	21	0	0	0
34	Kumar, Rajiv B.	Stanford University	USA	1	20	1	20	0	0	0
35	Wang, Hua-Qiong	Zhejiang University	China	1	20	1	20	0	0	0
36	Benhamou, P-Y.	Joseph Fourier University, Grenoble, France	France	1	20	1	20	0	0	0
37	Prociow, Pawel A.	University of Nottingham, Nottingham, UK	UK	1	20	1	20	0	0	0
38	Rahimi, Alireza	UNSW, Australia	Australia	1	19	1	19	0	0	0
39	Herbek, S.	ELGA GmbH Vienna, Austria	Austria	1	19	1	19	0	0	0

Note: Abbreviations: author name – AN; country – CT; total paper – TP; total citation – TC; average citation per item – AC.

Table 4a   Authors productivity in EHMS (Web of Science) (continued)

Order	AN	Institution	CT	TP	TC	h-index	AC	≥200	≥100	≥50
40	Phansalkar, Shobha	Partners Healthcare Systems	USA	1	18	1	18	0	0	0
41	Kopanitsa, G.	German Research Center for Environmental Health, Neuherberg, Germany	Germany	1	18	1	18	0	0	0
42	Banerjee, Dipanjan	Stanford University	USA	1	18	1	18	0	0	0
43	Menon, Shailaja	Baylor College of Medicine	USA	1	16	1	16	0	0	0
44	Noblin, Alice	University of Central Florida	USA	1	16	1	16	0	0	0
45	Makam, Anil N.	University of California San Francisco	USA	1	15	1	15	0	0	0
46	Zhang, Jianguo	Shanghai Institute of Technical Physics	China	1	15	1	15	0	0	0
47	Guo, Rui	Xi'an University	China	1	13	1	13	0	0	0
48	Dagher, Gaby G.	Boise State University	USA	1	12	1	12	0	0	0
49	Goldstein, David H.	Queen's University	Canada	1	12	1	12	0	0	0
50	Newsham, Alexander C.	University of Leeds	UK	1	12	1	12	0	0	0
51	Xiao, Liang	Royal College of Surgeons in Ireland	Ireland	1	12	1	12	0	0	0
52	Marimon-Sunol, Santiago	epartament de Salut, Generalitat de Catalunya, Barcelona, España	Spain	1	11	1	11	0	0	0
53	Grant, C.	University of Adelaide	Australia	1	11	1	11	0	0	0
54	Yadav, Pranjul	University of Minnesota - Twin Cities	USA	1	10	1	10	0	0	0
55	van Velthoven, Michelle Helena	Imperial College London	UK	1	10	1	10	0	0	0

Note: Abbreviations: author name – AN; country – CT; total paper – TP; total citation – TC; average citation per item – AC.

Table 4a   Authors productivity in EHMS (Web of Science) (continued)

Order	AN	Institution	CT	TP	TC	h-index	AC	≥200	≥100	≥50
56	Liu, Chung-Feng	Chia Nan University of Pharmacy and Science	Taiwan	1	10	1	10	0	0	0
57	Shea, Christopher M.	University of North Carolina-Chapel Hill	USA	1	10	1	10	0	0	0
58	Kontio, Elina	University of Turku	Finland	1	10	1	10	0	0	0
59	Heart, Tsipi	Ono Academic College	Israel	1	9	1	9	0	0	0
60	Jawhari, Badeia	University of Alberta	Canada	1	9	1	9	0	0	0
61	Gagnon, Marie-Pierre	Université Laval	Canada	1	9	1	9	0	0	0
62	McAlearney, Ann Scheck	Ohio State University	USA	1	9	1	9	0	0	0
63	Tundia, Namita L.	University of Cincinnati	USA	1	9	1	9	0	0	0
64	Navarro, Ronald A.	South Bay Medical Center	USA	1	9	1	9	0	0	0
65	del Carmen Legaz-Garcia, Maria	Universidad de Murcia, Spain	Spain	1	8	1	8	0	0	0
66	Sajatovic, Martha	Case Western Reserve University	USA	1	8	1	8	0	0	0
67	Park, Sun Young	University of California, Irvine	USA	1	8	1	8	0	0	0
68	Cardoso de Moraes, Joao Luis	Federal University of São Carlos	Brazil	1	7	1	7	0	0	0
69	Al Mallah, Amr	Montreal Heart Institute Pharmacogenomics Centre;	Canada	1	7	1	7	0	0	0
70	Kharrazi, Hadi	Johns Hopkins Bloomberg School of Public Health	USA	1	6	1	6	0	0	0
71	Plantier, Morgane	Centre de lutte contre le cancer Léon Bérard	France	1	6	1	6	0	0	0

Note: Abbreviations: author name – AN; country – CT; total paper – TP; total citation – TC; average citation per item – AC.

Table 4a   Authors productivity in EHMS (Web of Science) (continued)

Order	AN	Institution	CT	TP	TC	h-index	AC	≥200	≥100	≥50
72	de Ruiter, Hans-Peter	Minnesota State University	USA	1	6	1	6	0	0	0
73	Somolinos, Roberto	University Hospital Puerta de Hierro Majadahonda	Spain	1	6	1	6	0	0	0
74	McCoy, Allison B.	Tulane University School of Public Health and Tropical Medicine	USA	1	6	1	6	0	0	0
75	Marceglia, S.	U.S. National Library of Medicine	USA	1	6	1	6	0	0	0
76	Hazlehurst, Brian L.	Kaiser Permanente Northwest Center for Health Research	USA	1	6	1	6	0	0	0
77	Zaninelli, M.	Università Telematica San Raffaele Roma	Italy	1	6	1	6	0	0	0
78	McEwen, Timothy R.	Wright State University	USA	1	6	1	6	0	0	0
79	De Pietro, Carlo	University of Applied Sciences and Arts of Southern Switzerland	Switzerland	1	5	1	5	0	0	0
80	Wang, Shirley V.	Harvard Medical School, Boston, MA, USA	USA	1	5	1	5	0	0	0
81	Matton, Marie-Pier	Sainte-Justine Hospital, Montreal, Québec	Canada	1	5	1	5	0	0	0
82	Kafi, Mohamed Amine	University of Science and Technology Houari	Algeria	1	5	1	5	0	0	0
83	Petrakaki, Dimitra	University of Sussex	UK	1	5	1	5	0	0	0
84	Fernando, Bernard	University of Edinburgh	UK	1	5	1	5	0	0	0
85	Poulymeno poulou, M.	University of Piraeus, Greece	Greece	1	5	1	5	0	0	0

Note: Abbreviations: author name – AN; country – CT; total paper – TP; total citation –
TC; average citation per item – AC.

Table 4b　Authors productivity in EHMS (Scopus)

Order	AN	Institution	CT	TP	TC	h-index	AC	≥200	≥100	≥50
1	Chang, P.H.	Lawrence Technological University	USA	1	5	1	5	0	0	0
2	Makela, K.	Tampere University of Technology	Finland	1	5	1	5	0	0	0
3	Bar-Lev, S.	Ruppin Academic Centre	Israel	1	4	1	4	0	0	0
4	Asghar, M.R.	University of Auckland	New Zealand	1	2	1	2	0	0	0
5	Pascal, C.J.	Rutgers University	USA	1	2	1	2	0	0	0

Note: Abbreviations: author name – AN; country – CT; total paper – TP; total citation – TC; average citation per item – AC.

Table 4c　Most productive institutions in EHMS (Web of Science)

Order	Institution	Total paper	Total citation
1	Harvard Medical School	6	190
2	Zhejiang University	3	49
3	Medical University of South Carolina	3	71
4	University of Texas	2	197
5	Cornell University	2	37
6	The University of Western Ontario	2	76
7	Imperial College London	2	53
8	Baylor College of Medicine	2	47
9	Stanford University	2	38
10	London School of Medicine and Dentistry	1	134
11	London School of Economics and Political Science	1	117
12	University of Surrey	1	73
13	Virginia Tech, USA	1	72
14	University of Washington	1	51
15	University of Haifa	1	51
16	NHS Foundation Trust, UK	1	45
17	Chinese University of Hong Kong	1	45
18	Vanderbilt University, USA	1	38
19	IBM TJ Watson Research Center	1	36
20	National Chung Hsing University	1	35
21	University of California at Los Angeles	1	29
22	University College London	1	28
23	Georgia State University	1	27
24	Inha University	1	25
25	Ilmenau University of Technology	1	23

Table 4c   Most productive institutions in EHMS (Web of Science) (continued)

Order	Institution	Total paper	Total citation
26	Indiana University	1	23
27	Institut de réadaptation en déficience physique de Québec	1	23
28	NorthShore University	1	22
29	Loyola University	1	22
30	McMaster University	1	21
31	Joseph Fourier University, Grenoble, France	1	20
32	University of Nottingham, Nottingham, UK	1	20
33	UNSW, Australia	1	19
34	ELGA GmbH Vienna, Austria	1	19
35	Partners Healthcare Systems	1	18
36	German Research Center for Environmental Health, Neuherberg, Germany	1	18
37	University of Central Florida	1	16
38	University of California San Francisco	1	15
39	Shanghai Institute of Technical Physics	1	15
40	Xi'an University	1	13
41	Boise State University	1	12
42	Queen's University	1	12
43	University of Leeds	1	12
44	Royal College of Surgeons in Ireland	1	12
45	Departament de Salut, Generalitat de Catalunya, Barcelona, España	1	11
46	University of Adelaide	1	11
47	University of Minnesota - Twin Cities	1	10
48	Chia Nan University of Pharmacy and Science	1	10
49	University of North Carolina-Chapel Hill	1	10
50	University of Turku	1	10
51	Ono Academic College	1	9
52	University of Alberta	1	9
53	Université Laval	1	9
54	Ohio State University	1	9
55	University of Cincinnati	1	9
56	South Bay Medical Center	1	9
57	Universidad de Murcia, Spain	1	8
58	Case Western Reserve University	1	8
59	University of California, Irvine	1	8
60	Federal University of São Carlos	1	7
61	Montreal Heart Institute Pharmacogenomics Centre	1	7

Table 4c   Most productive institutions in EHMS (Web of Science) (continued)

Order	Institution	Total paper	Total citation
62	Johns Hopkins Bloomberg School of Public Health	1	6
63	Centre de lutte contre le cancer Léon Bérard	1	6
64	Minnesota State University	1	6
65	University Hospital Puerta de Hierro Majadahonda	1	6
66	Tulane University School of Public Health and Tropical Medicine	1	6
67	U.S. National Library of Medicine	1	6
68	Kaiser Permanente Northwest Center for Health Research	1	6
69	Università Telematica San Raffaele Roma	1	6
70	Wright State University	1	6
71	University of Applied Sciences and Arts of Southern Switzerland	1	5
72	Sainte-Justine Hospital, Montreal, Québec	1	5
73	University of Science and Technology Houari	1	5
74	University of Sussex	1	5
75	University of Edinburgh	1	5
76	University of Piraeus, Greece	1	5

Table 4d   Most productive institutions in EHMS (Scopus)

Order	Institution	Total paper	Total citation
1	Lawrence Technological University	1	5
2	Tampere University of Technology	1	5
3	Ruppin Academic Centre	1	4
4	University of Auckland	1	2
5	Rutgers University	1	2

In Web of Science, Wright, Adam has three papers in the list being the most productive author in EHMS, while Sittig, Dean; Ancker, Jessica; Li, Jing-Song and Teufel, Ronald have two papers each. We observed that the first three most productive authors are affiliated to institutions in the USA. All authors shown in our result on Scopus have one paper each; hence, Chang and Makela have been ranked as the most productive authors in Scopus in EHMS within the period we have reviewed. Table 4a and 4b presents this result in detail for all the 96 papers included as part of our review.

Tables 4c and 4d show the most productive institutions in EHMS, Harvard medical school leads the table in Web of Science; interestingly, Wright, Adam who is the most productive author in Web of Science from our result and analysis is affiliated to this institution. Zhejiang University and Medical University of South Carolina took the second and third places; further investigation reveals that these three institutions have dedicated more resources to medical research in their respective regions and have leaped to top rank among other institutions in terms of medical research funding and output.

All institutions identified in Scopus have same number of papers; hence, we have ranked based on the number of citations; Lawrence Technological University and Tampere University of Technology are the most productive institutions on Scopus with one paper each in EHMS within the period we reviewed. Although these two institutions are rated high in terms of quality medical research; however, this result is considerably low number compared to the result from Web of Science, this may possibly be connected to the fact that researchers tend to be interested more in Web of Science than Scopus, due to the international and multidisciplinary nature of the database to obtain literature in technology, science, medicine and other fields (Chadegani et al., 2013).

Table 4e   Most productive and influential countries in EHMS (Web of Science)

Order	Country	Total paper	Total citation	h-index	Average citations per item
1	USA	43	1060	21	24.65
3	UK	11	492	9	44.7
5	Canada	9	162	7	18
2	China	6	112	6	18.67
13	Spain	3	25	3	8.33
4	Israel	2	60	2	30
8	Germany	2	41	2	20.5
9	France	2	26	2	13
10	Australia	2	30	2	15
6	Hong Kong	1	45	1	45
7	South Korea	1	25	1	25
11	Austria	1	19	1	19
12	Ireland	1	12	1	12
14	Taiwan	1	10	1	10
15	Finland	1	10	1	10
16	Brazil	1	7	1	7
17	Italy	1	6	1	6
18	Switzerland	1	5	1	5
19	Algeria	1	5	1	5
20	Greece	1	5	1	5

Table 4f   Most productive and influential countries in EHMS (Scopus)

Order	Country	Total paper	Total citation	h-index	Average citations per item
1	USA	2	7	2	3.5
2	Finland	1	5	1	5
3	Israel	1	4	1	4
4	New Zealand	1	2	1	2

In terms of the most productive and influential countries in EHMS, USA is clearly the leading country in both Web of Science and Scopus based on our result. This analysis is

detailed in Table 4c, where on Web of Science, USA takes the lead, followed by UK and Canada; USA also takes the lead again in Scopus. From our observation during the analysis, we noted that more about 47% of the institutions in our analysis are from the USA, 11% from the UK and 8% from Canada, making those three countries the most influential in EHMS. This is unsurprising, as these three identified countries are prominent in providing adequate funding and resources for medical research and implementation of new medical systems, periodic upskilling of medical practitioners in area of technology to ease usability of new systems, and organising regular sessions to raise awareness of new medical systems, which is having positive effects on the altitude, perception and adoption of new medical systems in the regions.

4.3   Leading continents and sources in EHMS

In Table 5, we have performed analysis of publications based on continent. The trend seems to be the same, as our result in both Web of Science and Scopus clearly shows that North America is the most productive region, with Europe and Asia taking the second and the third place respectively. However, taking into consideration paper per million inhabitants, the results are not so significant. Oceania and Africa are the least in EHMS in terms of productively, our result reveals that Africa has the lowest publication in EHMS on Web of Science and Scopus compared to other regions. Finally, Table 6 presents the most productive sources in EHMS, we have arranged this based on the total number of papers published in the sources from 2008 to 2018.

Table 5a   Publication based on continent (Web of Science)

Order	Continent	TP	TC	h-index	CP	≥250	≥100	≥50	PMI	CMI
1	America	53	1229	22	23.19	0	1	5	0.067	1.548
2	Europe	24	641	12	26.71	0	2	3	0.032	0.858
3	Asia	11	252	10	22.91	0	0	1	0.002	0.055
4	Oceania	2	30	2	15.00	0	0	0	0.071	0.759
5	Africa	1	5	1	5.00	0	0	0	0.001	0.004

Note: Abbreviations: total paper – TP; total citation – TC; cites per paper – CP; paper per million inhabitants – PMI; cites per million inhabitants – CMI.

Table 5b   Publication based on continent (Scopus)

Order	Continent	TP	TC	h-index	CP	≥250	≥100	≥50	PMI	CMI
1	America	2	7	2	3.50	0	0	0	0.003	0.009
2	Europe	1	5	1	5.00	0	0	0	0.001	0.007
3	Asia	1	4	1	4.00	0	0	0	0.0002	0.0009
4	Oceania	1	2	1	2.00	0	0	0	0.024	0.047
5	Africa	0	0	0	0.00	0	0	0	0	0

Note: Abbreviations: total paper – TP; total citation – TC; cites per paper – CP; paper per million inhabitants – PMI; cites per million inhabitants – CMI.

Table 6a   Most productive sources in EHMS (Web of Science)

Order	Source title	Total paper	Impact factor
1	JOURNAL OF THE AMERICAN MEDICAL INFORMATICS ASSOCIATION	13	4.292
2	INTERNATIONAL JOURNAL OF MEDICAL INFORMATICS	7	2.731
3	BMC MEDICAL INFORMATICS AND DECISION MAKING	7	2.067
4	JOURNAL OF BIOMEDICAL INFORMATICS	5	2.95
5	JOURNAL OF MEDICAL SYSTEMS	5	2.415
6	QUALITY & SAFETY IN HEALTH CARE	2	2.16
7	BMJ OPEN	2	2.376
8	BMC HEALTH SERVICES RESEARCH	2	1.932
9	PLOS ONE	2	2.776
10	ACADEMIC PEDIATRICS	2	2.537
11	COMPUTER METHODS AND PROGRAMS IN BIOMEDICINE	2	3.424
12	BMJ-BRITISH MEDICAL JOURNAL	1	27.604
13	MEDICAL CARE RESEARCH AND REVIEW	1	2.577
14	CANADIAN FAMILY PHYSICIAN	1	2.186
15	JOURNAL OF GENERAL INTERNAL MEDICINE	1	4.606
16	JOURNAL OF HOSPITAL INFECTION	1	3.704
17	MOUNT SINAI JOURNAL OF MEDICINE	1	1.623
18	MEDICAL CARE	1	3.795
19	IEEE TRANSACTIONS ON INFORMATION TECHNOLOGY IN BIOMEDICINE	1	2.493
20	INFORMATION SYSTEMS RESEARCH	1	2.457
21	ACADEMIC MEDICINE	1	5.083
22	CIN-COMPUTERS INFORMATICS NURSING	1	1.029
23	ARTIFICIAL INTELLIGENCE IN MEDICINE	1	3.574
24	DIABETES & METABOLISM	1	3.263
25	TECHNOLOGY AND HEALTH CARE	1	0.787
26	EUROPEAN SURGERY-ACTA CHIRURGICA AUSTRIACA	1	0.483
27	METHODS OF INFORMATION IN MEDICINE	1	1.024
28	AMERICAN JOURNAL OF HYPERTENSION	1	2.53
29	INTERNATIONAL JOURNAL OF COMPUTER ASSISTED RADIOLOGY AND SURGERY	1	2.155
30	IEEE ACCESS	1	4.098
31	SUSTAINABLE CITIES AND SOCIETY	1	4.624
32	CANADIAN JOURNAL OF ANESTHESIA-JOURNAL CANADIEN D ANESTHESIE	1	3.374
33	COMPUTERS IN BIOLOGY AND MEDICINE	1	2.286
34	MEDICINA CLINICA	1	1.277
35	ANAESTHESIA AND INTENSIVE CARE	1	1.358

Table 6a   Most productive sources in EHMS (Web of Science) (continued)

Order	Source title	Total paper	Impact factor
36	ACM COMPUTING SURVEYS	1	6.131
37	HEALTH POLICY AND TECHNOLOGY	1	1.225
38	INTERNATIONAL JOURNAL OF HEALTH POLICY AND MANAGEMENT	1	4.485
39	CLINICAL ORTHOPAEDICS AND RELATED RESEARCH	1	4.154
40	KNOWLEDGE-BASED SYSTEMS	1	5.101
41	EPILEPSY & BEHAVIOR	1	2.378
42	ACM TRANSACTIONS ON COMPUTER-HUMAN INTERACTION	1	1.734
43	PERSONALIZED MEDICINE	1	1.414
44	JOURNAL OF MEDICAL INTERNET RESEARCH	1	4.945
45	NURSING PHILOSOPHY	1	1.071
46	IEEE JOURNAL OF BIOMEDICAL AND HEALTH INFORMATICS	1	4.217
47	APPLIED CLINICAL INFORMATICS	1	1.306
48	AMERICAN JOURNAL OF PREVENTIVE MEDICINE	1	4.435
49	JOURNAL OF HEALTHCARE ENGINEERING	1	1.295
50	HEALTH POLICY	1	2.075
51	JOURNAL OF PEDIATRIC INTENSIVE CARE	1	-
52	SOCIAL SCIENCE & MEDICINE	1	3.087
53	PERSONAL AND UBIQUITOUS COMPUTING	1	1.735

Table 6b   Most productive sources in EHMS (Scopus)

Order	Source title	Total paper	Impact factor
1	Proceedings – 2011 International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery, CyberC 2011	1	-
2	Telemedicine and e-Health	1	1.996
3	Sociology of Health and Illness	1	2.211
4	Medical Data Privacy Handbook	1	-
5	Journal of Information and Knowledge Management	1	-

Our result reveals that Journal of the American Medical Informatics Association is the most productive source on Web of Science, followed by International Journal of Medical Informatics and BMC Medical Informatics and Decision Making taking the second and third place. We have also included in our analysis the impact factors of these sources at the time of our study and we have identified few observations below:

- *Quality and Safety in Health Care*, which was ranked no. 6 in terms of productivity based on our analysis, it had impact factor of 2.160 on Web of Science and this was shown as being updated last in 2012. However, the information is different on the journal homepage, the impact factor was noted as 7.043.

- *Mount Sinai Journal of Medicine* was ranked no. 17 in terms of productivity (based on our analysis), it had impact factor of 1.623 on Web of Science and this was shown as being updated last in 2014.

- *IEEE Transaction on Information Technology in Biomedicine* was ranked no. 19 in terms of productivity (based on our analysis), it had impact factor of 2.493 on Web of Science and this was shown as being updated last in 2014.

Proceedings of 2011 International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery, Telemedicine and e-Health are the leading in terms of most productive sources in EHMS on Scopus.

5   Graphical analysis of EHMs with VOSviewer

The study runs a bibliometric analysis with VOSviewer version 1.6.13 (Van Eck, & Waltman 2010) to create bibliometric maps with items, links, and clusters for the purpose of identifying the milestones in research area of EHMS and to examine the areas that makes up EHMS and how they connect to each other. This study extracted data from two bibliographic databases of Web of Science and Scopus that contains the metadata of authors, year of publications, cited references, affiliations, source, volume, issue, pages, digital object identifier (DOI), abstract, keywords and document type for comprehensive analysis and comparison. The study based on the recommendation of (Van Eck and Waltman, 2010) also examined the co-citation of journals, a bibliographic coupling of authors, bibliographic coupling of institutions, citation analysis of institutions, co-authorship of institutions, a bibliographic coupling of countries and co-occurrence of author keywords.

It is important to understand how co-citation works and its application in this study. Co-citation harmonises the two items that are published in separate journals that receive a citation from another journal item. In Figures 2(a) and 2(b), this study has the graphical representation of journals co-citation between 2008 to 2018 from both Web of Science and Scopus. For Web of Science, we set the threshold to 85 and out 1,548 sources, only three sources meet the set threshold. To expand the scope of the sources, we set reduced the threshold to 2 and out of 1548, only 341 sources meet the threshold and the analysis with two threshold reveals 11 clusters of sources and the first clusters records 50 items. In all, the *Journal of the American Medical Informatics Association* had the total link strength of 11,286. In comparison with Scopus map network, there are distant differences in the weight of sources of Web of Science regarding EHMS based on clusters but on the part of Scopus, there was no distinct demarcation of the sources weight but the Scopus map network link was dense with some sources at the borders [Figures 2(a) and 2(b)].

Figure 2   (a) Co-citation of journals cited in EHMS (Web of Science) (b) Co-citation of
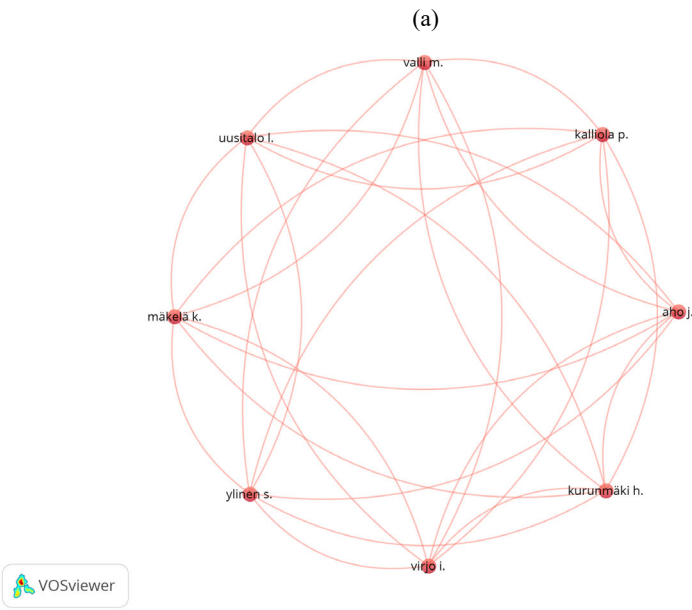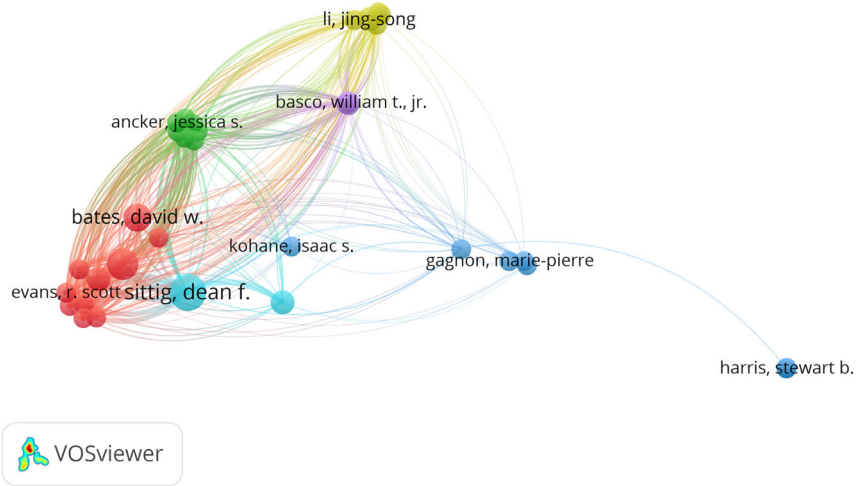journals cited in EHMS (Scopus) (see online version for colours)
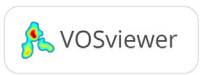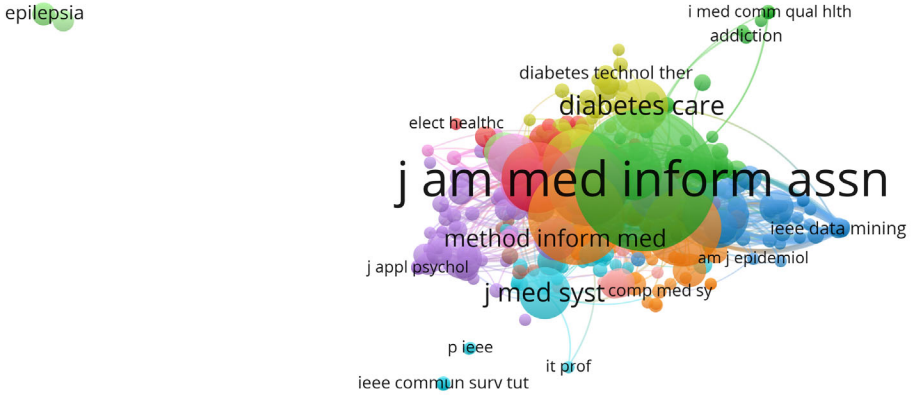

(a)
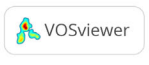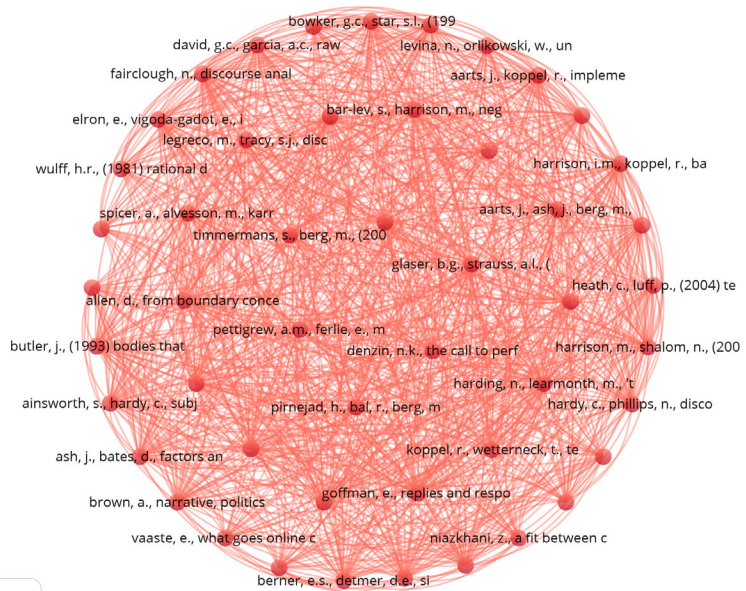
(b)

Figure 3   (a) Bibliographic coupling of authors that published in EHMS (Web of Science)
   (b) Bibliographic coupling of authors that published in EHMS (Scopus)

(a)

(b)

We compare bibliographic coupling of authors in Figures 3(a) and 3(b). We used the thresholds of 4 and out of 477 authors, 3 meets the set thresholds. We also used the threshold of 2, and only 34 authors meet the criteria. The higher the thresholds, the lower the number of authors that reaches the limit. The analysis shows six clusters and the first cluster had ten items. Among the 34 authors, Sittig, Dean and Singh, Hardeep had total link strength more than the other authors. The network map of Web of Science in the field of EHMS is more densely than Scopus network map [Figures 3(a) and 3(b)].

Regarding bibliographic coupling of institutions, four thresholds shows that out of 233 institutions, five meet the thresholds while two thresholds shows that 34 meets the thresholds with seven clusters and the first cluster records eleven items. Harvard University had the highest total link strength of 1,650, which indicate the relatedness between two items. Some institutions in Web of Science clustered closely while the institutions in Scopus have distance relatedness [Figures 4(a) and 4(b)].

Figure 4   (a) Bibliographic coupling of institutions that published in EHMS (Web of Science)
(b) Bibliographic coupling of institutions that published in EHMS (Scopus) (see online version for colours)
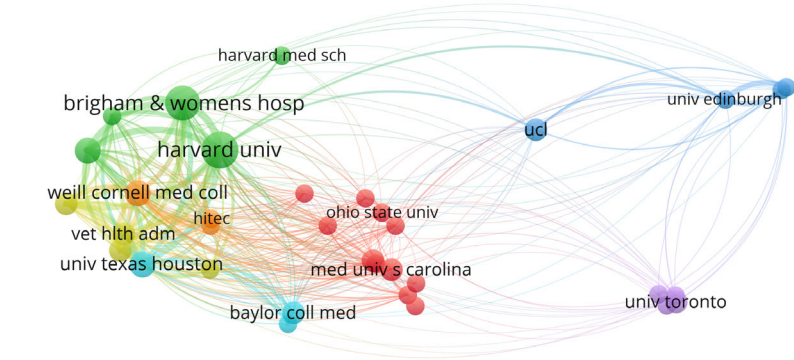
(a)
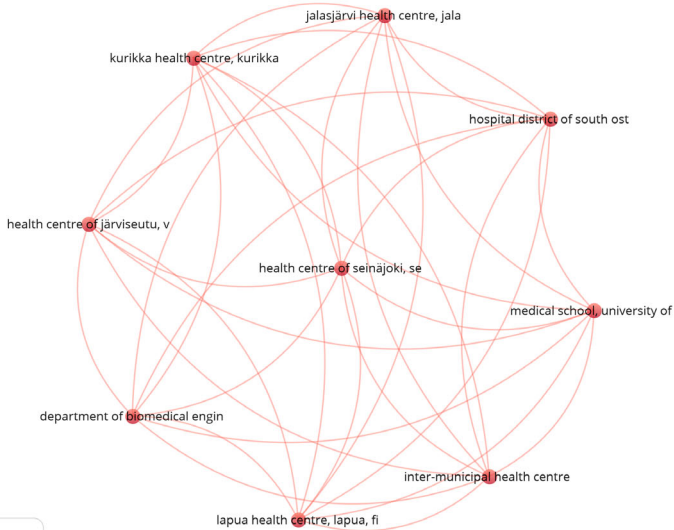
(b)

Figure 5   (a) Citation analysis of countries that published in EHMS (Web of Science) (b) Citation analysis of countries that published in EHMS (Scopus) (see online version for colours)

(a)
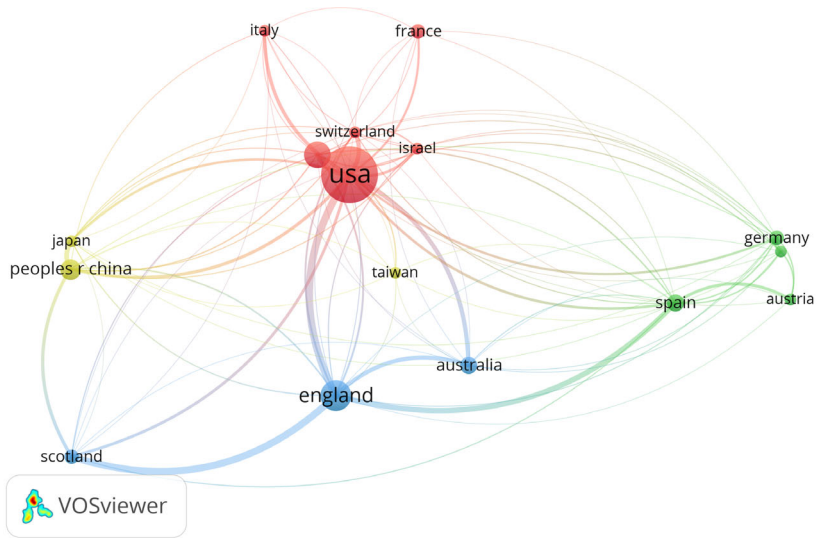
(b)

As shown in Figures 5(a) and 5(b), the Web of Science output for EHMS with thresholds of 10 shows that out of the 28 countries generated, three countries reached the thresholds while with 2 thresholds, 16 countries conforms to the set thresholds. The Vosviewer generate four clusters and the first cluster reveals six items. The six countries in cluster one falls to North America, Europe and Israel (Middle East). The USA had the highest

citations with 9 total link strength. Unlike Web of Science link strength, the Scopus had four clusters without any link strength.

Figure 6   (a) Co-authorship of institutions that published in EHMS (Web of Science)
(b) Co-authorship of institutions that published in EHMS (Scopus) (see online version for colours)

(a)

(b)
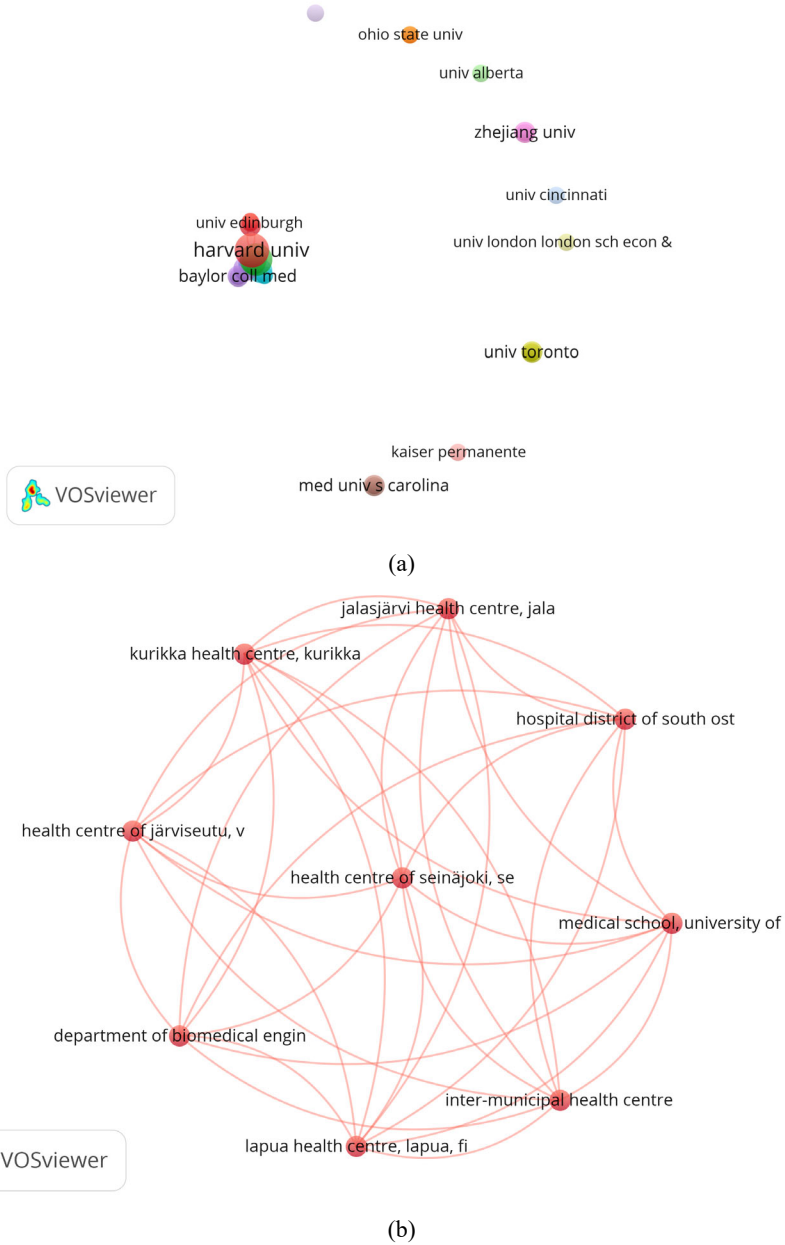
Initially, we set the thresholds of 4 and out of 233 institutions, five meet the thresholds in Web of Science. We also tried the thresholds of 2 and out of the 233 institutions, 34 meet the thresholds. The 34 institutions formed 13 clusters and the highest densely cluster had five items and they consists Harvard University, UCI, University of Edinburgh, University of Leeds and University of London Imperial College. The co-authorship of institutions is a combination of clustered institutions with link strengths and institutions without link strengths. The Scopus co-authorship of institutions map network were connected with uniform weights.

Table 7a   Most frequent author's keyword in EHMS (Web of Science)

Cluster	No. of items	Author keywords
1	7	decision-support, impact, implementation, information-technology, physician order entry, quality, systems
2	6	electronic health records, information, medical-records, prevalence, primary-care, risk
3	5	adoption, electronic medical records, health-care, hospitals, physicians
4	4	care, electronic health record, management, technology

Table 7b   Most frequent author's keyword in EHMS (Scopus)

Cluster	No. of items	Author keywords
1	2	electronic health records, electronic medical records
2	1	electronic health record

Lastly, we examine the co-occurrence of author keywords and all keywords of health records in Web of Science and author keywords in Scopus in Figures 7(a), 7(b), and 7(c). Using 6 as thresholds for authors keywords analysis, out of 301 keywords generated, only 3 meets the thresholds and while using the thresholds of 2, out of the 301 keywords, only 26 reach the set verge, forming 8 clusters and the first cluster had 6 items. In all keywords, two thresholds reveal 568 keywords shows 109 keywords that the meet the set thresholds with 7 clusters and the first clusters with 32 items. In author's keywords, electronic health records had the highest total link strength, followed by electronic health record with 11 total link strength, health information technology with 8 total link strength, electronic medical records and semantic interoperability with 7 total link strength. For all keywords, management had 121 total link strength, followed by information-technology with 111 total link strength, electronic health records with 102, physicians with 61, implementation with 58. Physician order entry with 38, electronic health record and decision-support with 37 total link strength. For Scopus, only three keywords emerged and they electronic medical record, electronic health records, organisation and management. Management and electronic health records are common in the Web of Science and Scopus.

Figure 7   (a) Co-occurrence of author keywords of documents published in EHMS (Web of Science) (b) Co-occurrence of author keywords of documents published in EHMS (Web of Science) (c) Co-occurrence of author keywords of documents published in EHMS (Scopus) (see online version for colours)
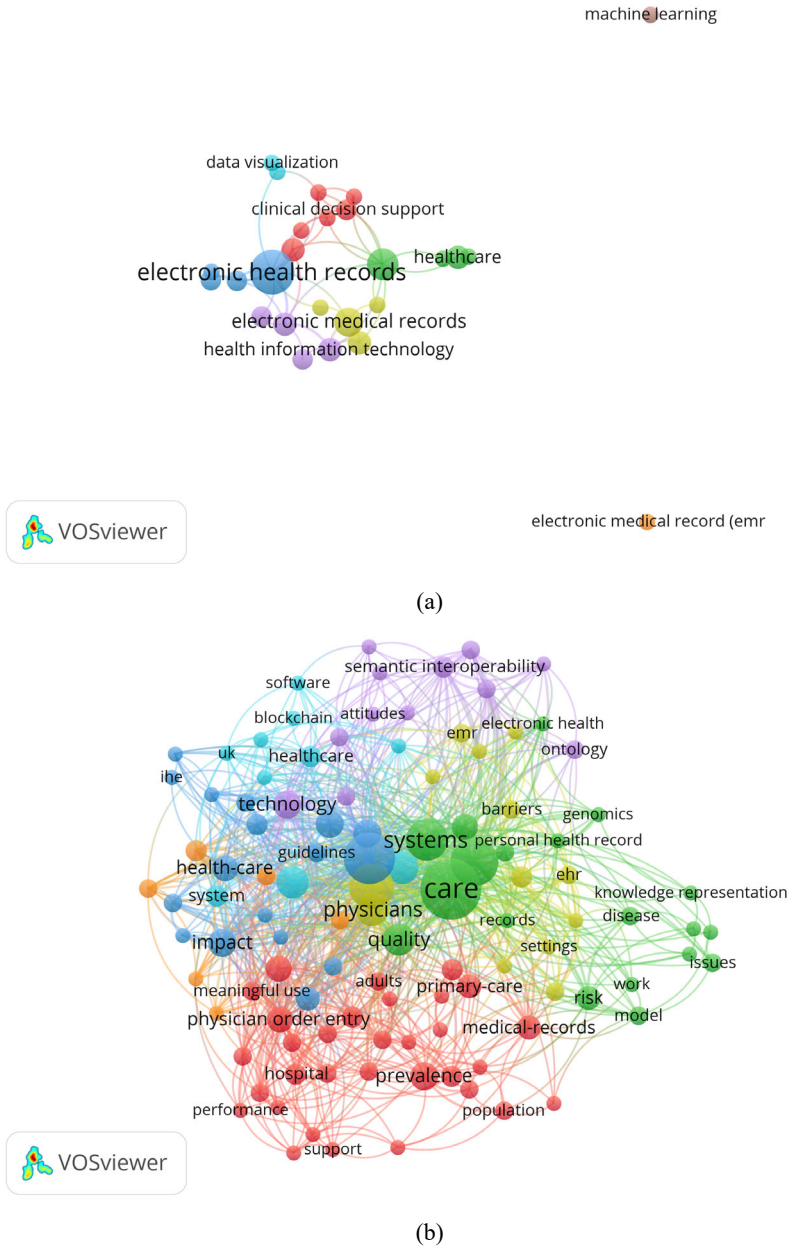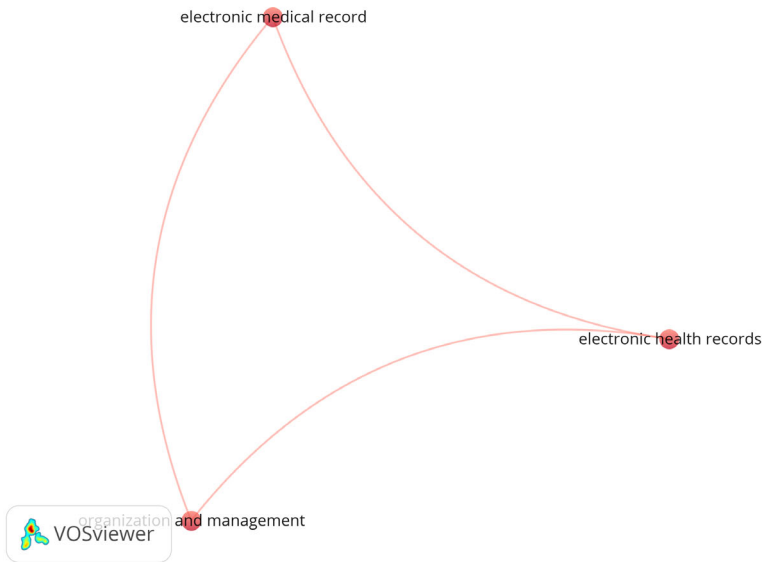

(a)

(b)

Figure 7 (a) Co-occurrence of author keywords of documents published in EHMS (Web of Science) (b) Co-occurrence of author keywords of documents published in EHMS (Web of Science) (c) Co-occurrence of author keywords of documents published in EHMS (Scopus) (continued) (see online version for colours)

(c)

6   Summary and conclusions

This study searched for publications related to EHMS in two databases (Web of Science and Scopus) between 2008–2018, We selected 96 EHMS related papers in total out of 508 publications found (91 were from Web of Science and five from Scopus). Particularly, it is worth noting that this study found only a relatively small number of literatures focused on EHMS adoption, influence and implementation. This lack of research literature and relevant information may have contributed largely to the slow adoption and implementation of EHMS globally, which is more notable in Africa and Oceania from our analysis and result. Our results provide insight into the research and publication trends on the implementation, influence, and adoption of EHMS over the period reviewed, and we have been able to demonstrate with our results how research in this area have evolved over time.

In analysing our research result from the bibliometric analysis of the 96 EHMS related papers, we noted that Wright, Adam has three papers in this review, making him the most productive author in EHMS on WoS based on our ranking on the number of publications for each author. Sittig, Dean; Ancker, Jessica; Li, Jing-Song and Teufel, Ronald; all had two papers each. Chang and Makela have been ranked as the most

productive author in Scopus in EHMS within the period we have reviewed with one paper each. The three most cited papers in Web of Science were written by Sittig, Dean; Greenhalgh, Trisha and Lluch, Maria with 171, 143 and 117, respectively. In Scopus, Chang; Makela, Virjo et al. and Bar-Lev represent the top-three most cited papers in EHMS.

It is worth noting that the yearly citation trend from Web of Science (WoS) reveals that 2010 and 2012 had the highest number of citations in EHMS with a total of 8 and 14 papers respectively and all the publications in Scopus on EHMS were published between 2010–2015. Our result also reveals that the numbers of citations and papers in EHMS is declining through time with 2017 seeing the least citations within the period under review. On Scopus, 2015 had the highest number of citations with a total of two papers, followed by 2010 and 2011 who both had five citations each. Our results show that there has been no paper published in EHMS since 2008–2009 and between 2016–2018 in Scopus.

It is also worth noting that our result further reveals Harvard medical school as the most productive institution in WoS; surprisingly, Wright, Adam who is the most productive author in WoS is affiliated to this institution; Zhejiang University and Medical University of South Carolina took the second and third places. We presumed that productivity of these institutions could have been as a result of dedicating more resources to medical research in their respective regions. Although Lawrence Technological University and Tampere University of Technology were observed as the most productive institutions in EHMS on Scopus with one paper each. We noted that this result is considerably low number compared to the result from Web of Science, this may possibly be connected to the fact that researchers tend to be interested more in Web of Science than Scopus, due to the international and multidisciplinary nature of the database to obtain literature in technology, science, medicine and other fields (Chadegani et al., 2013).

The most influential country in EHMS from WoS and Scopus based on our review was USA; interestingly, the first three most productive authors were affiliated to institutions in the USA. This is followed by UK and Canada being the second and third most productive countries. These three identified countries are prominent in providing adequate funding and resources for medical research, periodically upskilling their medical practitioners in area of technology and organising regular sessions to raise necessary awareness of new medical tools, which we believe is having positive effects on the altitude, perception and adoption of new medical systems in the regions.

Based on our result, North America is the most productive continent on EHMS, which has more than 58% of the total publications reviewed on EHMS in our study. Europe and Asia taking the second and the third place respectively. Oceania and Africa are the least influential continents in EHMS, which raise a major concern on the need to urgently investigate what constitute barriers in these regions in terms of EHMS.

In order to further expand on our bibliometric results, our study also develops a graphical visualisation of the results using the VOS viewer software, which shows the publication structure of authors, institutions, and countries, by using bibliographic coupling, co-authorship and citation analysis. The results agree with our section 4, where USA is clearly the most productive country.

As a limitation of this study, we have limited our search to only publications between 2008–2018 in the two databases; hence our study does not take into consideration years beyond this period. In addition, using 'English' as a limit during the search meant that we may have excluded key literatures on EHMS adoption and implementation written in another languages or that may have been authored by researchers who resides in countries with high adoption and implementation of EHMS who are not 'English' speakers.

In conclusion, our study has revealed the need to develop a strong evidence base research to support the use, adoption, influence and effective implementation of EHMS in health care institutions.

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