

“All Quiet on the Western Front” - Clinical Information Systems Research in the Year 2021

An Overview of the CIS Section of the IMIA Yearbook of Medical Informatics

Werner O. Hackl¹, Alexander Hoerbst², Section Editors for the IMIA Yearbook Section on Clinical Information Systems

¹ Institute of Medical Informatics, UMIT - Private University of Health Sciences, Medical Informatics and Technology, Hall in Tirol, Austria

² Medical Technologies Department, MCI - THE ENTREPRENEURIAL SCHOOL, Innsbruck, Austria

Summary

Objective: In this synopsis, we give an overview of recent research and propose a selection of best papers published in 2021 in the field of Clinical Information Systems (CIS).

Method: As CIS section editors, we annually apply a systematic process to retrieve articles for the IMIA Yearbook of Medical Informatics. For eight years now, we use the same query to find relevant publications in the CIS field. Each year we retrieve more than 2,400 papers which we categorize in a multi-pass review to distill a preselection of up to 15 candidate papers. External reviewers and yearbook editors then assess the selected candidate papers. Based on the review results, the IMIA Yearbook editorial board chooses up to four best publications for the section at a selection meeting. To get a comprehensive overview of the content of the retrieved articles, we use text mining and term co-occurrence mapping techniques.

Results: We carried out the query in mid-January 2022 and retrieved a deduplicated result set of 2,688 articles from 1,062 different journals. This year, we nominated ten papers

as candidates and finally selected two of them as the best papers in the CIS section. As in the previous years, the content analysis of the articles revealed the broad spectrum of topics covered by CIS research, but - on the other side - no real innovations or new upcoming research trends. However, the significant impact of COVID-19 on CIS research was observable also this year.

Conclusions: The trends in CIS research, as seen in recent years, continue to be observable. The content analysis revealed nothing really new in the CIS domain. What was very visible was the impact of the COVID-19 pandemic, which still effects our lives and also CIS.

Keywords

Medical informatics, International Medical Informatics Association, Yearbook, Clinical Information Systems

Yearb Med Inform 2022;146-51
<http://dx.doi.org/10.1055/s-0042-1742532>

some of which offered interesting approaches and solutions [1]. Other trends as observed in previous years continued. Among them patient-centeredness, trans-institutional information sharing, intelligent clinical data analytics capabilities, artificial intelligence, machine learning, and decision support. Telehealth services and networked, integrated care were other vital and rising topics for CIS research in the last years [2–5].

The special topic of the 2022 edition of the IMIA Yearbook of Medical Informatics had been defined as “Inclusive Digital Health: Addressing Bias, Equity, and Literacy to Strengthen Health Systems”. So, we were curious whether this topic was also reflected in the papers found in our selection.

2 About the Paper Selection

The selection process in the CIS section is stable now for eight years. We described it in detail in [2], and the full queries are available upon request.

We carried out the queries in mid-January 2022, and retrieved 2,688 unique papers. Of them, 2,354 were found in PubMed and an additional set of 334 papers (deduplicated) could be found in Web of Science®. The resulting articles had been published in 1,062 different journals. Table 1 depicts the top-15-ranked journals with the highest numbers of resulting articles.

1 Introduction

For eight years now, we are responsible for the CIS section of the IMIA Yearbook of Medical Informatics. In our search for the best papers in the field, we systematically screen more than 2,400 papers each year, retrieved from PubMed and Web of Science® (WoS) using standardized queries. By doing so, we also get a good overview of the research activities in the CIS field in general.

Additionally, every edition of the IMIA Yearbook is dedicated to a special topic that is reflected against the background of the retrieved papers.

Last year, the special focus was on “Managing Pandemics with Health Informatics: Successes & Challenges”. We were amazed at the strong influence of COVID-19 on CIS research and the high number of publications that addressed problems of information logistics for the management of the pandemic,

Again, most of those papers whose publication records included location information came from the United States (43%, n=591). England was next (30%, n=401), followed from the Netherlands (7%, n=96), Germany (4%, n=54) and Ireland (4%, n=52).

RAYYAN (<https://www.rayyan.ai>), an online systematic review tool has proven its worth for the multi-stage selection process of the best papers for many years now. We both (WOH, AH) independently reviewed all 2,688 publications and excluded ineligible articles based on their titles and/or abstracts in the first pass (WOH: n=2,616; AH: n=2,647), which resulted in an agreement rate of 96.1 percent (n=2,580 for "exclude", and n=4 for "not exclude" - i.e., "include"). We included the remaining papers with at least one vote for "include" (n=106) in the next screening round, where we selected 22 papers for full-text review on mutual consent.

This year, we selected ten candidate papers for the CIS 2021 section. For each of these candidate papers, at least six independent reviews were collected. The selection meeting with the IMIA Yearbook editorial board was – as in the two previous years – held as a video conference on April 29, 2022. In this meeting, two papers [6,7] were finally selected as the best papers for the CIS section (Table 2).

3 Findings and Trends: Clinical Information Systems Research 2021

Traditionally, we have used text mining and a bibliometric network visualizing approach [8] to summarize the articles' content and abstracts in our CIS result set. This helps us to put our overview of the section's content, which we get from screening and evaluating the publications, on a methodologically more stable footing.

Again, we extracted the authors' keywords (n=16,830) from all articles and presented their frequency in a tag cloud (Figure 1). We found 3,998 different keywords, of which 2,589 were only used once. As in the previous years, the most frequent

Table 1 Number of retrieved articles for top-15 ranked journals (n=16).

Rank	Journal	Number of papers
1	Journal of medical Internet research	82
2	Journal of the American Medical Informatics Association: JAMIA	70
3	PLoS one	61
4	Health communication	48
5	BMC medical informatics and decision making	43
6	Applied clinical informatics	39
7	International journal of environmental research and public health	37
8	Computers, informatics, nursing: CIN	30
9	BMC health services research	28
10	Scientific reports	27
11	International journal of medical informatics	27
12	Journal of biomedical informatics	26
13	JAMA network open	25
14	Expert opinion on drug safety	20
15	Sensors (Basel, Switzerland)	19
	Patient education and counseling	17

Table 2 Best paper selection of articles for the IMIA Yearbook of Medical Informatics 2022 in the section 'Clinical Information Systems'. The articles are listed in alphabetical order of the first author's surname.

Section
Clinical Information Systems
<ul style="list-style-type: none"> Harris B, Ajisola M, Alam RM, Watkins JA, Arvanitis TN, Bakibinga P, Chipwaza B, Choudhury NN, Kibe P, Fayehun O, Omigbodun A, Owoaje E, Pemba S, Potter R, Rizvi N, Sturt J, Cave J, Iqbal R, Kabaria C, Kalalo A, Kyobutungi C, Lilford RJ, Mashanya T, Ndegese S, Rahman O, Sayani S, Yusuf R, Griffiths F. Mobile consulting as an option for delivering healthcare services in low-resource settings in low- and middle-income countries: A mixed-methods study. <i>Digit Health</i> 2021 Aug 19;7:20552076211033425. Lenert LA, Ilatovskiy AV, Agnew J, Rudisill P, Jacobs J, Weatherston D, Deans KR Jr. Automated production of research data marts from a canonical fast healthcare interoperability resource data repository: applications to COVID-19 research. <i>J Am Med Inform Assoc</i> 2021 Jul 30;28(8):1605-11.

keyword was "Humans" (n=1,467). "Electronic Health Records" was the second most frequent keyword (n=455), followed by "Female" (n=418), "Male" (n=370), "Adult" (n=275). The next, "Point-of-Care Systems" was defined in 10% of the retrieved papers (n=265).

In contrast to the keyword tag cloud, the bibliometric network can reveal more details on the content of the CIS publications by showing the most relevant terms of titles

and abstracts and their association. Figure 2 depicts the resulting co-occurrence map of the top-500 terms (n=507, most relevant 60% of the terms) from the abstracts of the 2,688 papers of the recent CIS result set.

The cluster analysis of titles and summaries did not reveal any significant changes compared to last year's results. Five clusters emerged that are very similar to those of last year. The red cluster on the left (n=217 entries) and the green cluster

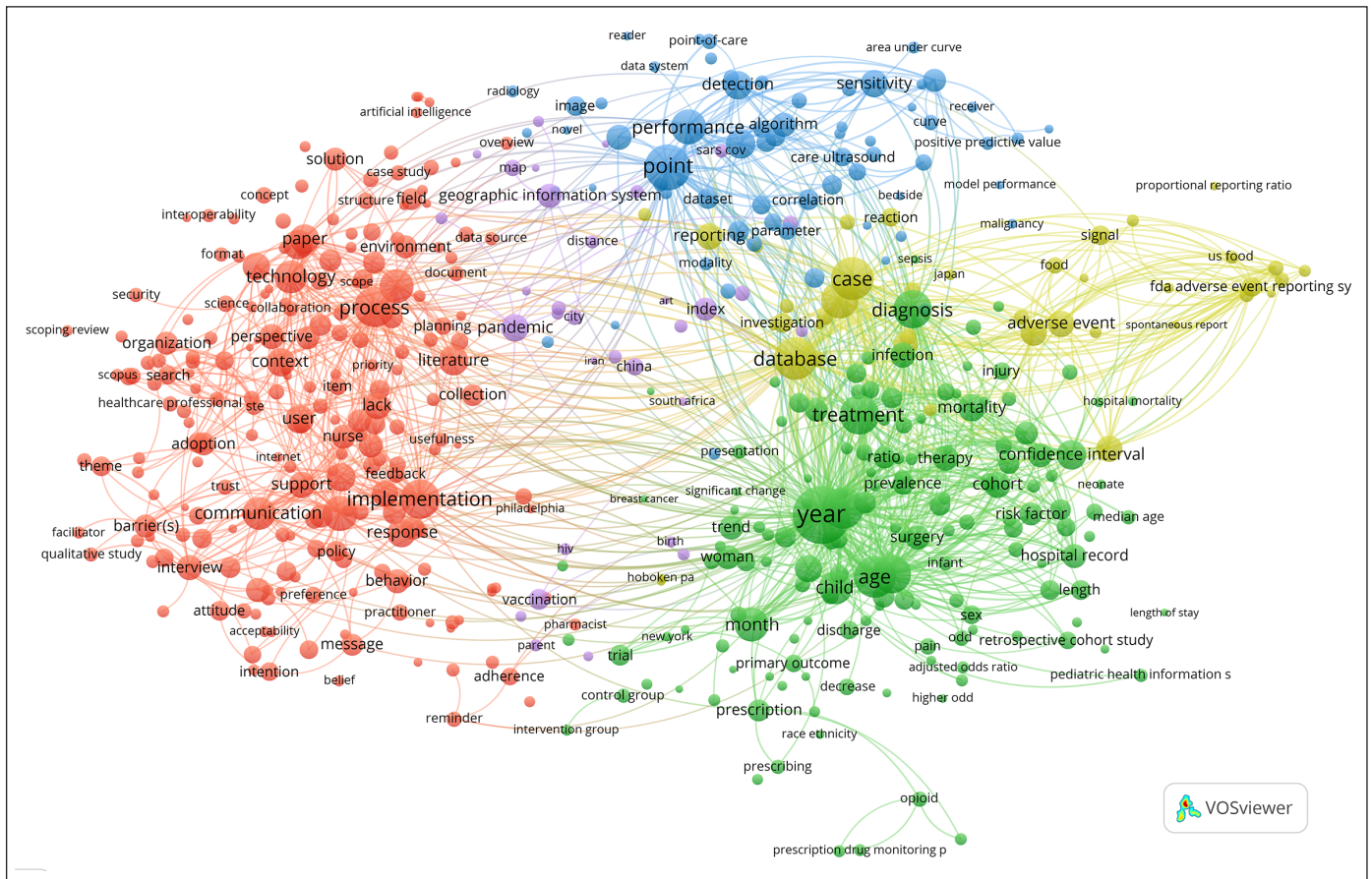


Fig. 2 Clustered co-occurrence map of the top-500 terms (top 60% of the most relevant terms: $n=507$ out of 61,563) from the titles and abstracts of the 2,688 papers in the 2022 CIS query result set. Only terms that were found in at least 17 different papers were included in the analysis. Node size corresponds to the frequency of the terms (binary count, once per paper, year: $n=615$). Edges indicate co-occurrence (only the top 1,000 of 69,561 edges are shown). The distance of nodes corresponds to the association strength of the terms within the texts. Colors represent the five different clusters. The network was created with VOSviewer [9].

services in low-resource settings in low- and middle-income countries” [6] in the DIGITAL HEALTH journal. This study gives a good overview of mobile consulting that can be used not only in low- and middle-income countries, but also in other countries where there may be more rural, low-income areas or marginalized populations in other settings as well.

The second of the best papers in the CIS section comes from the COVID-19 “corner”. Leslie A. Lenert *et al.*, tackle a very technical problem with Fast Healthcare Interoperability Resources (FHIR) and its consequences following COVID-19. Their paper is titled “Automated production of research data marts from a canonical fast healthcare interoperability resource data repository:

applications to COVID-19 research” and was published in the Journal of the American Medical Informatics Association [7].

Although the remaining candidates were not selected as best papers, they are all fine and interesting contributions that show different aspects of research in the CIS context. In the following, we would like to briefly present them.

Artificial Intelligence (AI) and deep learning are very hot topics in the CIS field. Louis Létinier *et al.*, present an excellent piece of work of the use of AI for coding unstructured adverse drug reporting data [10]. The next candidate paper by Du *et al.*, shows an interesting example of deep learning to predict the risk of severe adverse effects from vaccines based on a retrospective re-

view of adverse event reports [11]. Another interesting contribution using deep learning comes from Saranya Sankaranarayanan *et al.*, who present a methodology for an alert system to flag mortality for COVID-19 positive patients by using laboratory values and electronic health record (EHR) data [12].

Another important aspect in CIS research is to find adequate ways of translating knowledge and sequences of recommended procedures into a computer understandable form, for implementation and quality of care control. Iago Avelino *et al.*, tried to do this and present a process-based modeling language for designing care pathways [13]. Another very technical approach to capture complex, time-varying features of a patient’s EHR data comes from Rui Meng *et al.*, [14].

Admittedly, the majority of reviewers found the content quite difficult to understand and perhaps beyond the interest of most readers. Nevertheless, this work is an interesting approach and perhaps a promising way to create new knowledge from large amount of complex time-series data.

The last three candidate papers come from completely different corners. CIS should primarily contribute to supporting health professionals in providing optimal health care. Keiko *et al.*, present a paper on the topic of smart hospital infrastructure [15]. They evaluated the positioning accuracy of geomagnetic indoor positioning in hospitals. A very practical work that can make us aware that improving positioning accuracy is crucial if we want to reap the benefits of smart hospital technologies. Finally, the last two candidate papers cover important aspects that we must never ignore if we want to live up to the claim of CIS as optimal tools for optimal health care. Joep Tummers *et al.*, compile the most relevant stakeholders, features, and obstacles of health information systems in their systematic literature review [16] and Tania Moerenhout *et al.*, throw light on patients' moral attitudes toward EHR [17].

As every year, at the end of our review of the results and trends of the Clinical Information Systems Section, we would like to recommend reading this year's survey article of the CIS Section, which is dedicated to the special topic "Inclusive Digital Health". Understanding the patient experience is important for researching and designing telemedicine and eHealth services to support patient care and wellbeing. Therefore, Johanna Viitanen, Paula Valkonen, Kaisa Savolainen, Nina Karisalmi, Sini Hölsä, Sari Kujala from the Department of Computer Science, Aalto University, Finland present a scoping review of approaches and recent trends of patient experience from an eHealth perspective [18].

4 Conclusions and Outlook

All in all, we could see that not much has really changed in the CIS section this year. Topics and trends in CIS research, as observed in the last few years, can still be observed.

The content analysis revealed nothing really new in the CIS section. However, the impact of the COVID-19 pandemic, which is still affecting our lives and also CIS, was clearly visible. That is why we alluded to the novel by Erich Maria Remarque in the title. This is by no means to say that nothing else was going on in the CIS section, that nothing was happening or that there were no high-quality publications. CIS are a vital field, nurtured by hard-working and innovative researchers. After eight years, our query is perhaps a little worn out and a little renewal is needed here too. We will see next year.

Acknowledgments

We would like to acknowledge the support of Fleur Mougín, Lina Soualmia, Adrien Ugon, Martina Hutter, and the whole Yearbook editorial team, as well as the numerous reviewers in the selection process of the best papers.

References

- Hackl WO, Hoerbst A; Section Editors of the IMIA Yearbook Section on Clinical Information Systems. Clinical Information Systems Research in the Pandemic Year 2020. *Yearb Med Inform* 2021 Aug;30(1):134-40.
- Hackl WO, Ganslandt T. Clinical Information Systems as the Backbone of a Complex Information Logistics Process: Findings from the Clinical Information Systems Perspective for 2016. *Yearb Med Inform* 2017 Aug;26(1):103-9.
- Hackl WO, Hoerbst A; Section Editors for the IMIA Yearbook Section on Clinical Information Systems. On the Way to Close the Loop in Information Logistics: Data from the Patient - Value for the Patient. *Yearb Med Inform* 2018 Aug;27(1):91-7.
- Hackl WO, Hoerbst A; Section Editors for the IMIA Yearbook Section on Clinical Information Systems. Managing Complexity. From Documentation to Knowledge Integration and Informed Decision Findings from the Clinical Information Systems Perspective for 2018. *Yearb Med Inform* 2019 Aug;28(1):95-100.
- Hackl WO, Hoerbst A; Section Editors for the IMIA Yearbook Section on Clinical Information Systems. Trends in Clinical Information Systems Research in 2019. *Yearb Med Inform* 2020 Aug;29(1):1218.
- Harris B, Ajisola M, Alam RM, Watkins JA, Arvanitis TN, Bakibinga P, et al. Mobile consulting as an option for delivering healthcare services in low-resource settings in low- and middle-income countries: A mixed-methods study. *Digit Health* 2021 Aug 19;7:20552076211033425.
- Lenert LA, Ilatovskiy AV, Agnew J, Rudisill P,

- Jacobs J, Weatherston D, et al. Automated production of research data marts from a canonical fast healthcare interoperability resource data repository: applications to COVID-19 research. *J Am Med Inform Assoc* 2021 Jul 30;28(8):1605-11.
- Waltman L, van Eck NJ, Noyons ECM. A unified approach to mapping and clustering of bibliometric networks. *J Informetr* 2010;4(4):629-35.
- van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* 2010 Aug;84(2):523-38.
- Létinier L, Jouganous J, Benkebil M, Bel-Létoile A, Goehrs C, Singier A, et al. Artificial Intelligence for Unstructured Healthcare Data: Application to Coding of Patient Reporting of Adverse Drug Reactions. *Clin Pharmacol Ther* 2021 Aug;110(2):392-400.
- Du J, Xiang Y, Sankaranarayananpillai M, Zhang M, Wang J, Si Y, et al. Extracting postmarketing adverse events from safety reports in the vaccine adverse event reporting system (VAERS) using deep learning. *J Am Med Inform Assoc* 2021 Jul 14;28(7):1393-400.
- Sankaranarayanan S, Balan J, Walsh JR, Wu Y, Minnich S, Piazza A et al. COVID-19 Mortality Prediction From Deep Learning in a Large Multistate Electronic Health Record and Laboratory Information System Data Set: Algorithm Development and Validation. *J Med Internet Res* 2021 Sep 28;23(9):e30157.
- Trajano IA, Ferreira Filho JB, de Carvalho Sousa FR, Litchfield I, Weber P. MedPath: A process-based modeling language for designing care pathways. *Int J Med Inform* 2021 Feb;146:104328.
- Meng R, Soper B, Lee HKH, Liu VX, Greene JD, Ray P. Nonstationary multivariate Gaussian processes for electronic health records. *J Biomed Inform* 2021 May;117:103698.
- Yamashita K, Oyama S, Otani T, Yamashita S, Furukawa T, Kobayashi D, et al. Smart hospital infrastructure: geomagnetic in-hospital medical worker tracking. *J Am Med Inform Assoc* 2021 Mar 1;28(3):477-86.
- Tummers J, Tekinerdogan B, Tobi H, Catal C, Schalk B. Obstacles and features of health information systems: A systematic literature review. *Comput Biol Med* 2021 Oct;137:104785.
- Moerenhout T, Devisch I, Cooreman L, Bernaerdt J, De Sutter A, Provoost V. Patients' moral attitudes toward electronic health records: Survey study with vignettes and statements. *Health Informatics J* 2021 Jan-Mar;27(1):1460458220980039.
- Viitanen J, Valkonen P, Savolainen K, Karisalmi N, Hölsä S, Kujala S. Patient Experience from an eHealth Perspective: A Scoping Review of Approaches and Recent Trends. *Yearb Med Inform* 2022:136-45.

Correspondence to

Dr. Werner O Hackl
Institute of Medical Informatics
UMIT – Private University for Health Sciences, Medical Informatics, and Technology
Eduard-Wallnoefer-Zentrum 1
6060 Hall in Tirol, Austria
Tel: + 43 50 8648 3806
E-mail: werner.hackl@umit-tirol.at