Journal : *JMMR (Jurnal Medicoeticolegal dan Manajemen Rumah Sakit), 12 (1): 64-74, April 2023*
Website : https://jmmr.umy.ac.id/index.php/jmmr
DOI : https://doi.org/10.18196/jmmr.v12i1.12

Bibliometric Analysis of Healthcare Failure Mode and Effect Analysis Research

Ariadne Aulia[1*], Elsye Maria Rosa[2]
** Correspondence Author : ariadneaulia@gmail.com*
[1] Master of Hospital Administration, Universitas Muhammadiyah Yogyakarta, Indonesia
[2] Master of Nursing, Universitas Muhammadiyah Yogyakarta, Indonesia

INDEXING

Keywords:
Bibliometric;
Healthcare Failure Mode and Effect Analysis;
HFMEA;
Scopus;
VOSviewer

ABSTRACT

Healthcare Failure Mode and Effect Analysis (HFMEA) has been widely used as a proactive risk assessment for healthcare processes since its development in 2001. This study performed a bibliometric analysis of published papers on HFMEA to map its utilization and evolutionary nuances. The dataset was obtained from the Scopus database for English-language papers published between 2002 and 2022 using "HFMEA" or "Healthcare Failure Mode and Effect Analysis" in the article title, abstract, or keywords. Microsoft Excel and VOSviewer were used to perform the analysis. We found 230 relevant publications during the study period. The year 2020 has the most publications, with 34 papers. Articles written by DeRosier et al. received the most citations (470). The United States had the highest number of published papers (84), while the United Kingdom had the most international collaboration. Co-occurrence analysis of author keywords showed that patient safety, risk assessment, and risk management were high-rank words. This study emphasized scholarly collaboration trends and identified relevant authors, topics, and journals on HFMEA research. It may assist health practitioners and healthcare facility managers in understanding the focus of HFMEA research. Nonetheless, the number of HFMEA publications is still sparse. Further studies on HFMEA in underrepresented medical specialties should be explored.

Kata kunci:
Bibliometrik;
Analisis Modus Kegagalan dan Dampak;
HFMEA;
Scopus;
VOSviewer

Healthcare Failure Mode and Effect Analysis (HFMEA) sudah dikenal luas sebagai sebuah metode penilaian risiko proaktif pada layanan kesehatan sejak diperkenalkan pada tahun 2001. Untuk mengetahui penggunaan dan perkembangan HFMEA secara global, studi ini melakukan analisis bibliometrik pada publikasi bertopik HFMEA. Sumber data berasal dari publikasi terindeks pada Scopus yang terbit pada tahun 2002 hingga 2022 dan menggunakan kata "HFMEA" atau "Healthcare Failure Mode and Effect Analysis" pada judul artikel, abstrak, atau kata kunci. Peneliti hanya mengikutsertakan artikel, review, dan artikel konferensi yang tertulis dalam bahasa Inggris. Analisis dilakukan dengan menggunakan aplikasi Microsoft Excel dan VOSviewer. Hasil penelitian menemukan 230 publikasi yang relevan. Tahun 2020 memiliki publikasi terbanyak dengan 34 artikel. Artikel yang ditulis oleh DeRosier et al. memiliki sitasi terbanyak (470). Amerika Serikat memiliki jumlah publikasi terbanyak (84) sedangkan Inggris memiliki kolaborasi internasional terbanyak. Analisis co-occurrence dari kata kunci peneliti menunjukkan bahwa keselamatan pasien, penilaian risiko, dan manajemen risiko merupakan kata kunci yang sering digunakan oleh peneliti. Studi ini mengungkapkan tren kolaborasi ilmiah dan mengidentifikasi penulis, topik, dan jurnal yang relevan terkait penelitian HFMEA. Hal tersebut dapat membantu praktisi kesehatan dan manajer fasilitas kesehatan dalam memahami fokus penelitian HFMEA. Meskipun demikian, publikasi dengan topik HFMEA masih jarang. Studi mengenai HFMEA pada beberapa spesialisasi medis yang masih kurang terwakili perlu dilakukan.

Article history: Received 2023-02-25; Revised 2023-03-11; Accepted 2023-03-16

INTRODUCTION

Healthcare Failure Mode and Effect Analysis (HFMEA) is a proactive risk assessment method widely used in healthcare facilities since its development in 2001. VA National Center for Patient Safety developed it by modifying FMEA to be specifically used in

evaluating processes in a healthcare setting (DeRosier et al., 2002). It focuses on identifying potential failures and preventing errors in healthcare processes. Over the years, several HFMEA modifications have been done to improve it (Rah et al., 2016; Soheylinia et al., 2019).

Bibliometric analysis is beneficial for measuring research activities in a specific area using published scientific literature. It relies on data from journals, titles, authors, and published paper references. The bibliometric analysis will interpret the quantitative details of papers (Kumar et al., 2022). This study aims to assess published papers on HFMEA, specifically to map the utilization of HFMEA and its evolutionary nuances in research globally by performing descriptive and relational bibliometric analysis.

RESEARCH METHOD

Bibliometric analysis is used in this study to evaluate research trends in HFMEA papers. We collected data from the Scopus database. The search criteria were "HFMEA" or "Healthcare Failure Mode and Effect Analysis." Medicine, Nursing, Pharmacology, Toxicology and Pharmaceutics, and Health Professions are the subject areas included. We limited the search to articles, reviews, and conference papers written in English. Papers published in 2023 were excluded.

Based on the defined criteria, the search equation used was (TITLE-ABS-KEY(hfmea) OR TITLE-ABS-KEY("healthcare failure mode* and effect* analysis")) AND (LIMIT-TO (SUBJAREA, "MEDI") OR LIMIT-TO (SUBJAREA, "NURS") OR LIMIT-TO (SUBJAREA, "PHAR") OR LIMIT-TO (SUBJAREA, "HEAL")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re") OR LIMIT-TO (DOCTYPE, "cp")) AND (LIMIT-TO (LANGUAGE, "English")) AND (EXCLUDE (PUBYEAR,2023)).

The researchers downloaded the data on January 24th, 2023, resulting in 263 documents. Data preparation and data cleaning were done to get accurate results. We excluded data in which author information was not available. The researchers also examined each paper and excluded those that did not discuss or implement HFMEA in their papers. The final dataset comprises 230 documents after 33 documents were excluded. The researchers cleaned data to ensure each paper's sources, authors, countries, and author keywords were labeled correctly. To analyze the data, we used Microsoft Excel 365 to get descriptive statistics and VOSviewer software to perform bibliometric analysis and visualize relationships graphically. A citation analysis of sources, authors, and documents, co-authorship analysis of countries, and co-occurrence analysis of author keywords was conducted. The research method is depicted in Figure 1.

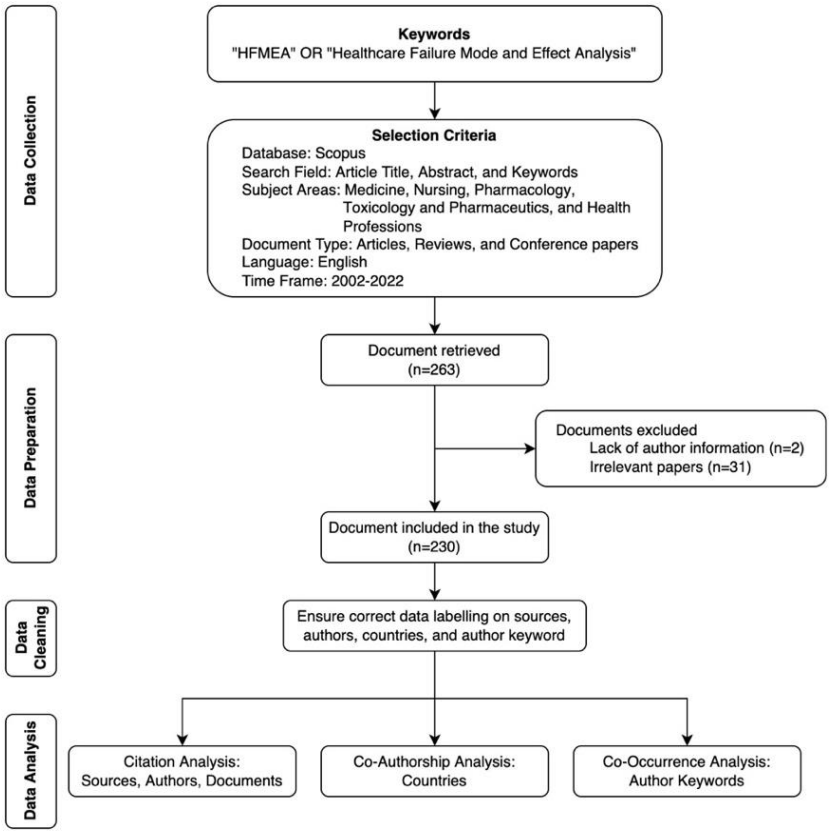

Figure 1. The Flow of Research Method

RESULT AND DISCUSSION

1. Overview

We analyzed 230 documents of HFMEA research indexed in the Scopus database from 148 sources and published from 2002 until 2022. Most of the papers were original research articles (217). Forty-seven countries have been publishing papers on HFMEA, and 1,321 authors have used 504 keywords to describe their papers. Table 1 shows the main characteristic of the dataset.

Table 1. Main Characteristics of The Dataset

	N (%)
Documents	
Article	217 (94.3)
Review	11 (4.8)
Conference Paper	2 (0.9)
Sources (Journal, etc.)	148
Countries	47
Authors	1,321
Author Keywords	504

2. *Annual Publication Growth*

The number of papers on HFMEA has been increasing steadily since 2002. Figure 2 shows the trends of published papers on HFMEA. 2020 has the most publications, with 34 papers, followed by 2019, with 30 papers.

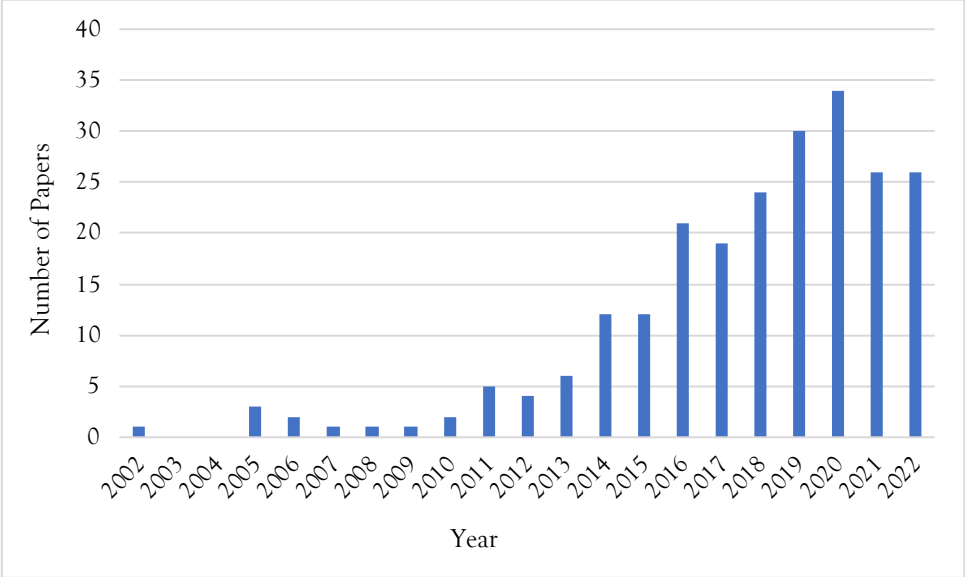

Figure 2. The Annual Publication Growth Trend of HFMEA Research

3. *Most Productive and Most Cited Journals*

The researchers found 149 published journals on HFMEA; the top five most prolific journals on HFMEA are shown in Figure 3. Medical Physics has the highest number of publications (8). Meanwhile, Joint Commission Journal on Quality and Patient Safety is the most cited journal, with 509 citations, followed by Medical Physics (137) and Quality and Safety in Health Care (112), as shown in Figure 4.

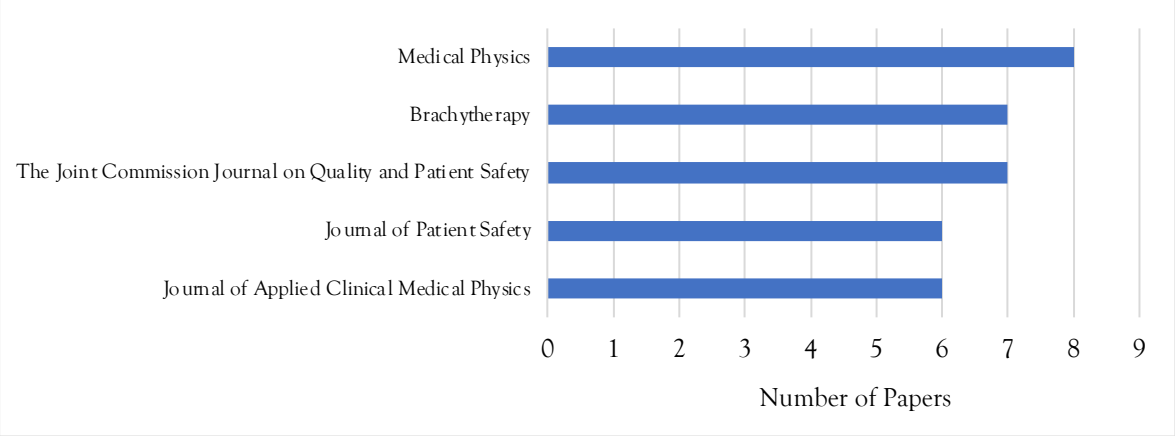

Figure 3. Most Productive Journals

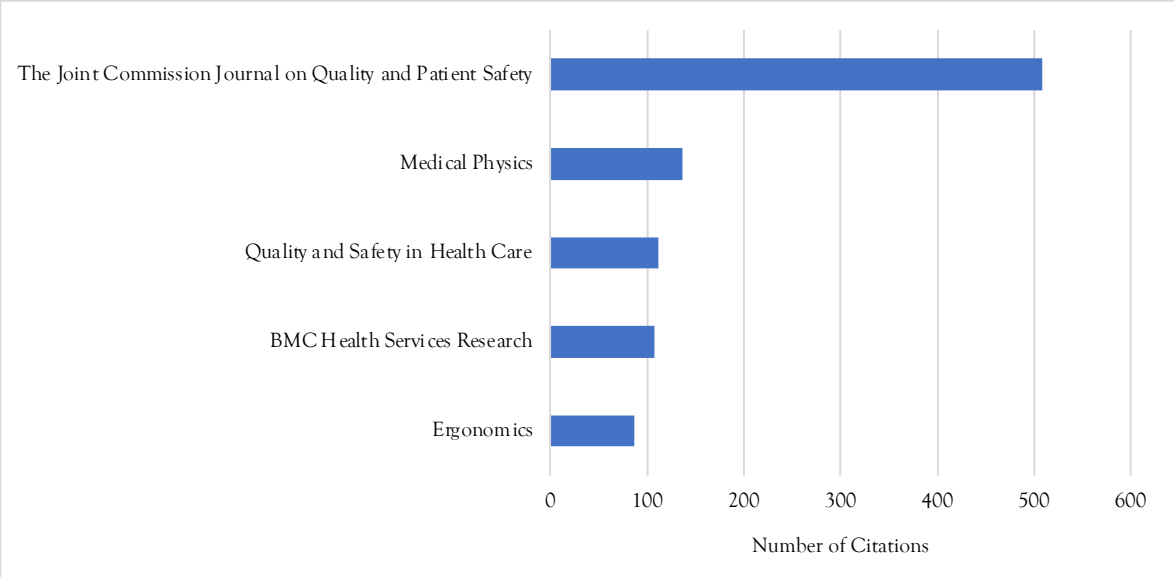

Figure 4. Most Cited Journals

4. Most Productive and Most Cited Authors

Among 1321 authors that have published papers on HFMEA, Ahmed K. was the most productive author with seven papers, followed by Dasgupta P. with five papers. However, the authors with the most citations are DeRosier J. and Bagian J.P., with 475 citations. Figure 5 shows the ten most cited authors.

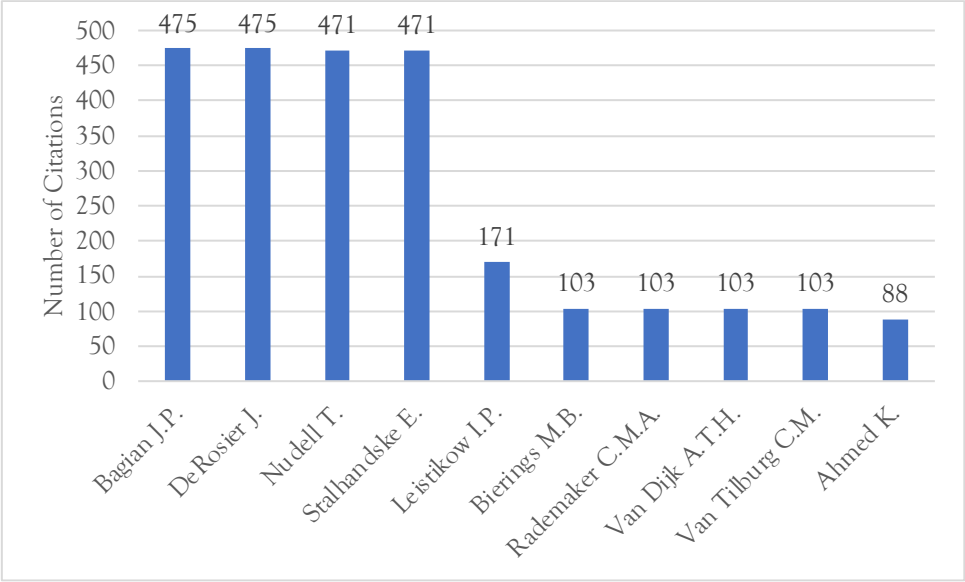

Figure 5. Top Ten Most Cited Authors

5. Most Cited Papers

Based on the number of citations, there are only two papers on HFMEA that over 100 papers have cited. The paper titled "Using health care Failure Mode and Effect Analysis: the VA National Center for Patient Safety's prospective risk analysis system" written by DeRosier

J., Stalhandske E., Bagian J.P., and Nudell T. is the highest-cited document with 470 citations. Table 2 shows the five most-cited documents on HFMEA research.

Table 2. Most-Cited Paper on HFMEA Research

Title	Author(s)	Journal	Year	Cited by
Using health care Failure Mode and Effect Analysis: the VA National Center for Patient Safety's prospective risk analysis system	DeRosier J., Stalhandske E., Bagian J.P., Nudell T.	The Joint Commission Journal on Quality Improvement	2002	471
Health care failure mode and effect analysis: A useful proactive risk analysis in a pediatric oncology ward	Van Tilburg C.M., Leistikow I.P., Rademaker C.M.A., Bierings M.B., Van Dijk A.T.H.	Quality and Safety in Health Care	2006	103
Applicability of healthcare failure mode and effects analysis to healthcare epidemiology: Evaluation of the sterilization and use of surgical instruments	Linkin D.R., Sausman C., Santos L., Lyons C., Fox C., Aumiller L., Esterhai J., Pittman B., Lautenbach E.	Clinical Infectious Diseases	2005	70
Prospective risk analysis of health care processes: A systematic evaluation of the use of HFMEA™ in Dutch health care	Habraken M.M.P., Van der Schaaf T.W., Leistikow I.P., Reijnders-Thijssen P.M.J.	Ergonomics	2009	68
Quality initiatives: Application of failure mode and effect analysis in a radiology department	Thornton E., Brook O.R., Mendiratta-Lala M., Hallett D.T., Kruskal JB.	Radiographics	2011	58

6. Co-Authorship Analysis of Countries

The researchers conducted a co-authorship analysis based on author affiliation countries (Figure 6). It revealed that the United States has the highest number of papers (84) and thus is the most productive. Meanwhile, even though there are only 26 papers published from the United Kingdom, it has the most international collaboration as it has 39 links strengths. The strength of the links indicates the number of publications in which the two countries appear together.

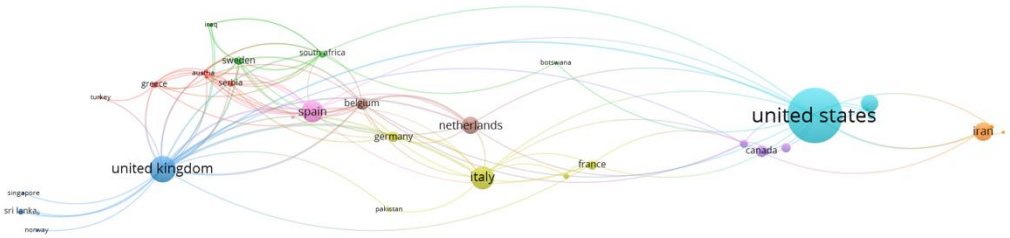

Figure 6. Co-authorship analysis of author affiliation countries

7. Co-occurrence analysis of author keywords

The researchers conducted a co-occurrence analysis of author keywords and limited the author keywords to at least two occurrences, and the analysis results are shown in Figure 7. The authors used the words Failure Mode and Effect Analysis (FMEA) the most (81), followed by Healthcare Failure Mode and Effect Analysis (HFMEA) (45). Patient safety, risk assessment, and risk management were also high-rank words chosen by authors in 36, 24, and 18 papers, respectively.

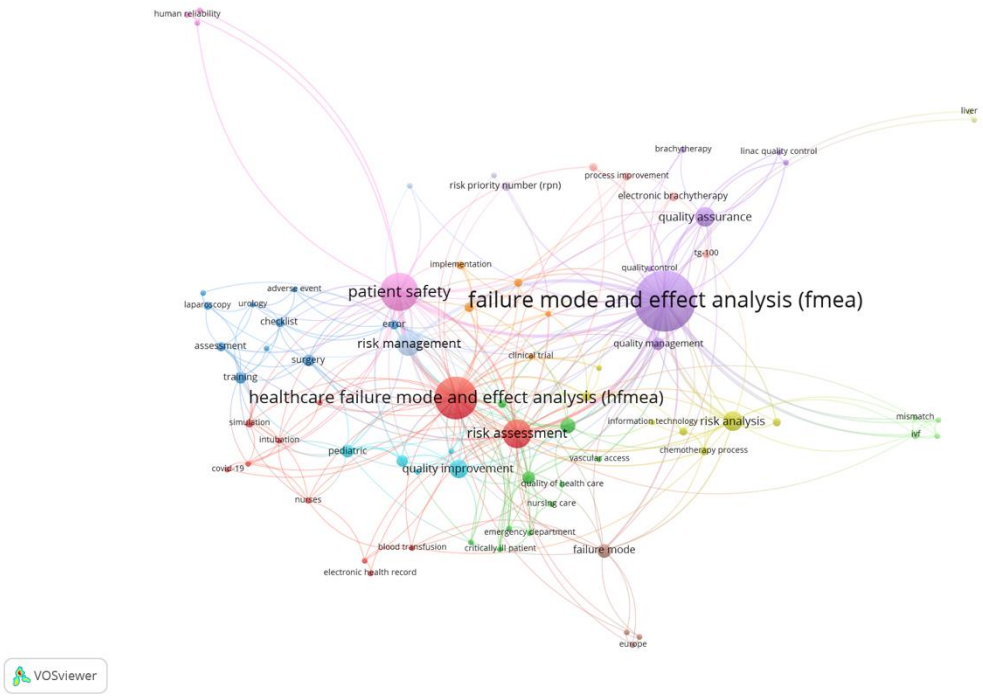

Figure 7. Co-occurrence analysis of author keywords

8. *Discussion*

This study used Scopus as the single database. Using only one database in the bibliometric analysis is a common and acceptable practice (Donthu et al., 2021). The researchers excluded papers published in 2023 to avoid underrepresented data because our study was conducted in early 2023. Our dataset contains 230 documents. As 200 papers were defined as possibly being an analytical minimum, our study has a sufficient sample size to represent the situation (Rogers et al., 2020).

Citation analysis of journals, authors, and documents was performed to analyze publication relationships by identifying the most influential publications in HFMEA research (Donthu et al., 2021). Medical Physics, Brachytherapy, and Journal of Applied Clinical Medical Physics are three of the five most productive journals on HFMEA research. All of them are journals that focus on medical physics disciplines. Medical physics is applied to studying the human body, its preservation, and the treatment of its illnesses (Duck, 2014). It is a medical field that combines physics and medicine. As FMEA was first developed to assess risks in the engineering process, medical physics that usually use machines in its healthcare process will benefit from it. The usage of HFMEA in radiotherapy, one of medical physic fields, has proven useful (Rah et al., 2016).

The most cited journal, most cited authors, and most cited papers were all related. The most cited journal, which is The Joint Commission Journal on Quality Improvement, is the one that published the most cited paper in HFMEA research. DeRosier J. and Bagian J.P. are the most cited authors; both wrote the most cited paper together. The most cited paper, titled *Using Health Care Failure Mode and Effect Analysis: The VA National Center for Patient*

Safety's Prospective Risk Analysis System is a guiding article on how to conduct HFMEA as developed by the Department of Veterans Affairs (VA) National Center for Patient Safety (DeRosier et al., 2002). It was not surprising to see that all of the most cited items, journal, author, and paper, were related to the paper mentioned above, given that all other papers using the HFMEA method need to cite this paper as their source of methodology.

Co-authorship analysis was conducted to investigate the relationships between authors and their affiliations and their impact on the advancement of the research field (Donthu et al., 2021). The United States was the pioneer in this area of research, followed by the United Kingdom. Both countries are ranked in the world's top three for scientific productivity by Scimago Journal & Country Rank, not only in all disciplines but also in the medicine category (SCImago, 2023). United States is also the country in which HFMEA was developed (DeRosier et al., 2002); therefore, it was not unexpected for it to be the leader in HFMEA research.

The author's keywords were investigated using co-occurrence analysis to examine the conceptual structure of a research field (Kumar et al., 2022). Failure Mode and Effect Analysis (FMEA) was the most used author keywords, as it was used to describe 81 papers. FMEA has been used by the engineering community since the 50s and was adopted in the development of HFMEA (DeRosier et al., 2002). Since it has been around for a longer time, several papers in healthcare settings still follow FMEA steps or modify FMEA by themselves to better adjust their needs (Alimohammadzadeh et al., 2017; Ghoushchi et al., 2021; Grau et al., 2021; Hakiem et al., 2022; Paradis et al., 2021). Patient safety, risk management, and risk assessment were among the top five most used author keywords. HFMEA was developed as a risk management and risk assessment method to improve patient safety in healthcare processes and has been proven to do so (Anjalee et al., 2021; Arenas Jiménez et al., 2017). As seen in the co-occurrence analysis results, no specific medical specialties dominated HFMEA research. Several medical specialties, such as pediatric and surgery, were used as author keywords. Other topics in medicine and the healthcare process could be explored to increase the variety of HFMEA studies.

This study is the first bibliometric analysis of the literature on HFMEA. This study's strengths include thoroughly examining papers through data preparation and cleaning. Because the scope of this study was limited to papers indexed in the Scopus database, searching in other databases may yield different sets of data and results from this analysis. A broader database search could be done to get a bigger dataset, and the results may give a new perspective.

CONCLUSION

Data visualization is a powerful tool for identifying and analyzing current and potential collaborative research. This study emphasized scholarly collaboration trends and identified the relevant authors, journals, and topics on HFMEA research. There were 230 relevant documents on HFMEA published between 2002 and 2022, with the year 2020 having the most publications. The Joint Commission Journal on Quality and Patient Safety was the most cited; meanwhile, Medical Physics was the most productive journal. The most cited authors were DeRosier J. and Bagian J.P., and the paper by DeRosier et al. received the most citations. The United States was the most prolific country, while the United Kingdom had

the most international collaboration. Based on co-occurrence analysis of author keywords, patient safety, risk assessment, and risk management were high-rank words, other than the criteria terms. By summarizing patterns in HFMEA research globally, the findings will hopefully provide better insight for health practitioners and healthcare facility managers in understanding the focus of HFMEA research. Nonetheless, the number of HFMEA publications is still sparse. Further studies on HFMEA in underrepresented medical specialties should be explored.

REFERENCES

Alimohammadzadeh, K., Bahadori, M., Jahangir, T., & Ravangard, R. (2017). Assessing common medical errors in a Children's hospital NICU using failure mode and effects analysis (FMEA) [Article]. *Trauma Monthly*, *22*(5), Article e15845. https://doi.org/10.5812/traumamon.15845

Anjalee, J. A. L., Rutter, V., & Samaranayake, N. R. (2021). Application of failure mode and effects analysis (FMEA) to improve medication safety in the dispensing process – a study at a teaching hospital, Sri Lanka [Article]. *BMC Public Health*, *21*(1), Article 1430. https://doi.org/10.1186/s12889-021-11369-5

Arenas Jiménez, M. D., Ferre, G., & Álvarez-Ude, F. (2017). Strategies to increase patient safety in Hemodialysis: Application of the modal analysis system of errors and effects (FEMA system) [Article]. *Nefrologia*, *37*(6), 608-621. https://doi.org/10.1016/j.nefroe.2017.11.011

DeRosier, J., Stalhandske, E., Bagian, J. P., & Nudell, T. (2002). Using health care Failure Mode and Effect Analysis: the VA National Center for Patient Safety's prospective risk analysis system [Article]. *The Joint Commission Journal on Quality Improvement*, 28(5), 248-267, 209. https://doi.org/10.1016/s1070-3241(02)28025-6

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, *133*, 285-296. https://doi.org/https://doi.org/10.1016/j.jbusres.2021.04.070

Duck, F. A. (2014). The origins of medical physics. *Physica Medica*, *30*(4), 397-402.

Ghoushchi, S. J., Dorosti, S., Rahman, M. N. A., Khakifirooz, M., & Fathi, M. (2021). Theory-based failure modes and effect analysis for medication errors [Article]. *Journal of Healthcare Engineering*, *2021*, Article 5533208. https://doi.org/10.1155/2021/5533208

Grau, N., Manzanera, R., Orrego, C., Ortner, J., Vives, A., Saurí, C., Moya, D., & Martínez, J. M. (2021). Risk management in the ambulatory care process in a mutual benefit association covering work-related accidents and diseases: Applying modified failure mode and effect analysis (FMEA) methodology [Article]. *Journal of Patient Safety*, *17*(8), E1428-E1432. https://doi.org/10.1097/PTS.0000000000000542

Hakiem, L., Dewanto, I., Sriyanto, S., & Jassey, B. (2022). Applying the Healthcare Failure Mode and Effect Analysis (HFMEA) Method for the Risk Management of Self-Developed Electronic Medical Records (EMRs) in Hospitals. *JMMR (Jurnal Medicoeticolegal dan Manajemen Rumah Sakit)*, *11*(3).

Kumar, M., George, R. J., & PS, A. (2022). Bibliometric Analysis for Medical Research. *Indian Journal of Psychological Medicine*, 0(0), 02537176221103617. https://doi.org/10.1177/02537176221103617

Paradis, K. C., Naheedy, K. W., Matuszak, M. M., Kashani, R., Burger, P., & Moran, J. M. (2021). The Fusion of Incident Learning and Failure Mode and Effects Analysis for Data-Driven Patient Safety Improvements [Article]. *Practical Radiation Oncology*, *11*(1), e106-e113. https://doi.org/10.1016/j.prro.2020.02.015

Rah, J. E., Manger, R. P., Yock, A. D., & Kim, G. Y. (2016). A comparison of two prospective risk analysis methods: Traditional FMEA and a modified healthcare FMEA [Article]. *Medical Physics*, *43*(12), 6347-6353. https://doi.org/10.1118/1.4966129

Rogers, G., Szomszor, M., & Adams, J. (2020). Sample size in bibliometric analysis. Scientometrics, 125(1), 777-794. https://doi.org/10.1007/s11192-020-03647-7

SCImago. (2023). *SJR – SCImago Journal & Country Rank*. Retrieved February 20th, 2023 from https://www.scimagojr.com/countryrank.php

Soheylinia, H., Sepehri, M. M., & Emadaldin, M. (2019). Reducing errors during surgery using an improved healthcare failure mode and effect analysis model [Article]. *British Journal of Health Care Management*, *25*(8), 1-15. https://doi.org/10.12968/bjhc.2017.0021