International Journal of Applied Research

ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor (RJIF): 8.4
IJAR 2024; 10(2): 111-115
www.allresearchjournal.com
Received: 03-01-2024
Accepted: 04-02-2024

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Demystifying the diseases diagnostic applicability of fuzzy logic methods: A meta-analysis

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Abstract
The landscape of medical diagnostics has witnessed a paradigm shift with the advent of fuzzy logic methods, offering a nuanced and adaaptable approach to handle the inherent uncertainty and imprecision in healthcare data. This meta-analysis seeks to demystify the diagnostic applicability of fuzzy logic methods in various diseases, providing a comprehensive synthesis of existing research findings. A systematic review was conducted across a diverse range of medical disciplines, encompassing studies that employed fuzzy logic methods for disease diagnosis. The meta-analysis involves the synthesis of data from numerous research articles, clinical trials, and case studies, focusing on the performance, reliability, and effectiveness of fuzzy logic-based diagnostic systems. The findings reveal a substantial body of evidence supporting the efficacy of fuzzy logic methods in disease diagnosis. Fuzzy logic has demonstrated a remarkable ability to model complex and dynamic relationships within medical datasets, accommodating uncertainty and imprecision inherent in diagnostic parameters. The meta-analysis highlights the versatility of fuzzy logic in handling diverse data types, including clinical, imaging, and molecular data, thereby providing a holistic perspective on its diagnostic applicability. Moreover, this study explores the impact of fuzzy logic-based diagnostic systems on clinical decision-making, emphasizing the potential for enhanced accuracy, early detection, and personalized treatment strategies. The meta-analysis also sheds light on the challenges and limitations associated with fuzzy logic methods in disease diagnosis, offering insights into areas for further refinement and improvement.

Keywords: Medical diagnostics, fuzzy logic methods, uncertainty and imprecision, healthcare data

Introduction
In the ever-evolving landscape of medical diagnostics, the integration of advanced computational methods has been pivotal in reshaping traditional approaches. The emergence of fuzzy logic methods represents a notable paradigm shift, providing a sophisticated and adaptable framework to address the inherent challenges of uncertainty and imprecision in healthcare data. As medical science grapples with the complexities of diagnosing various diseases, fuzzy logic has garnered attention for its ability to navigate the intricate nature of medical datasets. This meta-analysis endeavors to unravel the mysteries surrounding the diagnostic applicability of fuzzy logic methods across a spectrum of diseases. By synthesizing and scrutinizing a diverse array of research findings, clinical trials, and case studies, this study aims to offer a comprehensive overview of the role played by fuzzy logic in disease diagnosis. Through a systematic review spanning multiple medical disciplines, we seek to shed light on the performance, reliability, and effectiveness of fuzzy logic-based diagnostic systems. As we delve into the findings, a compelling body of evidence emerges, illustrating the efficacy of fuzzy logic in modeling complex and dynamic relationships within medical datasets. Fuzzy logic's unique capacity to accommodate the uncertainties inherent in diagnostic parameters positions it as a promising tool for improving diagnostic accuracy. This meta-analysis also explores the versatility of fuzzy logic, showcasing its ability to handle diverse data types, including clinical, imaging, and molecular data, thereby providing a holistic perspective on its diagnostic applicability. Moreover, the study delves into the impact of fuzzy logic-based diagnostic systems on clinical decision-making. By emphasizing the potential for enhanced accuracy, early detection, and the formulation of personalized treatment strategies, we aim to elucidate the transformative potential of fuzzy logic in shaping the future of medical diagnostics. However, the journey through the diagnostic landscape is not without challenges.

This meta-analysis will not only underscore the strengths of fuzzy logic methods but also critically examine the associated limitations. Insights into these challenges will pave the way for future refinements and improvements, fostering a more nuanced understanding of the role fuzzy logic can play in advancing the field of disease diagnosis.

Statement of the problem: The statement of the problem is as under:

"Demystifying the Diseases Diagnostic Applicability of Fuzzy Logic Methods: A Meta-Analysis"

Purpose of the study: The purpose of the study is as under
To determine the role of Diseases Diagnostic Applicability of Fuzzy Logic Methods in the domain of health.

Research assumption: Fuzzy logic methods are assumed to be relevant and applicable across a diverse range of medical disciplines.

Rationale of the study: The rationale behind undertaking a meta-analysis on demystifying the diseases diagnostic applicability of fuzzy logic methods stems from the evolving landscape of medical diagnostics and the increasing recognition of computational methodologies in healthcare. Traditional diagnostic approaches often struggle to navigate the complexities and uncertainties inherent in diverse medical datasets. Fuzzy logic, renowned for its ability to handle imprecision and uncertainty, presents a promising avenue for enhancing diagnostic precision. The diversity of medical data types, including clinical, imaging, and molecular data, underscores the need for versatile diagnostic tools. This study aims to synthesize existing knowledge from various medical disciplines through a meta-analysis, providing a comprehensive overview of fuzzy logic's role in disease diagnosis. By aggregating findings from different studies, the research seeks to identify trends, patterns, and consistencies across diseases, contributing to a robust understanding of fuzzy logic's effectiveness. Additionally, the exploration of fuzzy logic's impact on clinical decision-making, along with the identification of challenges and limitations, offers valuable insights for refining and improving its practical application. Ultimately, the study's rationale lies in its potential to inform future innovations, address gaps in current diagnostic approaches, and positively influence healthcare outcomes through a more nuanced and evidence-based understanding of fuzzy logic's diagnostic applicability. According to Ahmadi, H. (2017) [1] The main goal was to assess the effect of fuzzy methods and their frequency on improving diagnosis to decrease errors in misdiagnosis, with meta-analysis systematic review. According to Houssein, E. (2023) [13] In the contemporary landscape of medical diagnostics, the analysis of diverse and abundant medical data has become pivotal for accurate disease diagnoses. This encompasses a wide array of data sources, including disease types, disease-related proteins, ligands for proteins, and molecular drug components. According to Awotunde, J. B. (2020) [5] Apart from prescription and treatments, diagnosis of the ailments remains a primary duty of medical personnel and the creation of an automated diagnostic system assist in decision making and easy and fast discovery of ailment affecting a patient. As per Jabiyeva, A. (2023) [14] the impact of medical diagnostics features on decision support system quality. It introduces soft computing methodologies and their applications in medicine, focusing on formalized expert information for diagnoses and symptoms. The study presents a fuzzy logic-based method for generating diagnostic inferences during therapeutic examinations. KohleE, S. (2009) [21] introduces an innovative on-line disease diagnosis system for soybean, employing a fuzzy-logic approach enriched by the rule-promotion or empowerment methodology for enhanced diagnostic judgments. The system integrates intelligent multimedia capabilities through text-to-speech conversion tools. According to Garibaldi, J. (2020) [9] The resultant fuzzy expert system explicitly represented uncertainty in both the input data and the knowledge base. According to Jemal, H. (2017) [15] Intensive Care Unit (ICU) is a complex healthcare environment especially in diagnostic tasks, when we recurrently deal with inaccurate information (accessible information is occasionally vague, inadequate, or incorrect). As per BanyDomi, K. (2020) [6] This paper delves into the practical applications of Fuzzy logic in clinical settings, highlighting its evolution in creating intelligent Fuzzy diagnostic systems over the past decade. Focused on Type-2 fuzzy logic, various authors have applied it to simplify rules for both straightforward and complex issues. According to Arji, G. (2023) [4] the key application field of the fuzzy logic in an infectious disease was related to dengue fever, hepatitis and tuberculosis. According to Bhavsar, K. (2021) [7] Medical diagnosis, with its inherent complexities, poses challenges due to overlapping structures, distractions, and human visual system limitations. To address these issues, machine learning (ML) methods have been increasingly employed to aid clinicians in making informed and accurate decisions in disease diagnosis. As per Kechaou, Z. (2018) [20] In areas of medical diagnosis and decision-making, several uncertainty and ambiguity shrouded situations are most often imposed. In this regard, one may well assume that intuitionistic fuzzy sets (IFS) should stand as a potent technique useful for demystifying associated with the real healthcare decision-making situations. According to Jindal, N. (2020) [16] Renal cancer is a serious and common type of cancer affecting old ages. The growth of such type of cancer can be stopped by detecting it before it reaches advanced or end-stage. Hence, renal cancer must be identified and diagnosed in the initial stages. In this research paper, an intelligent medical diagnostic system to diagnose renal cancer is developed by using fuzzy and neuro-fuzzy techniques. According to Ahmadi (2018) [2] emphasizes the pivotal role of diagnosis as the initial step in medical practice, acknowledging its significance in complex clinical decision-making amid inherent ambiguity and uncertainty in the field of medicine. Given the inseparable nature of uncertainty in medicine, Ahmadi underscores the utility of fuzzy logic methods as effective tools for mitigating ambiguity. While numerous literatures exists on fuzzy logic methods in medical diagnosis, there is a scarcity of recent review articles, with most belonging to a decade ago. In response, Ahmadi conducts a systematic review to assess the contributions of fuzzy logic methods in disease diagnosis across various medical practices. As per Arji, G. (2019) [4] A comprehensive and systematic review of the literature is presented, focusing on the application of fuzzy logic in the context of infectious diseases. Despite the significant global impact of emerging infectious diseases on health and economics, a thorough examination of fuzzy logic applications in this domain has been lacking. This study represents the inaugural effort in providing a systematic and comprehensive academic review and classification of fuzzy logic methods in the realm of infectious diseases. According to Niswati. (2017) [23] focuses on implementing a Decision Support System (DSS) in the health sector, specifically for the early diagnosis of Diabetes Mellitus using the Fuzzy Logic method. The primary objective is to empower individuals, including laypeople, to conduct early diagnosis and initiate prompt treatment. Decision Support System Techniques are employed to enhance the decision-making process for improved effectiveness. As per Hasan, M. (2010) [18] delves into the complexities of human disease diagnosis, emphasizing the need for a high level of expertise in the process. The paper outlines a project dedicated to overcoming the challenges associated with developing a web-based expert system for human disease diagnosis using fuzzy logic. Fuzzy systems, increasingly successful in various applications, employ linguistic rules to describe complex systems. Alkholy, E. (2020) [3] addresses the challenges of decision-making in environments rife with uncertain, vague, and imprecise information. Acknowledging the difficulties in training computer systems to emulate human thinking for accurate decision-making, the paper proposes a fuzzy model specifically tailored for diagnosing bone diseases. The primary objective is to demonstrate the efficacy of fuzzy logic in replicating human expertise, allowing the system to provide accurate diagnostic answers akin to those of a human expert doctor. Ivana Dragović (2015) [27] contributed to the field by developing a fuzzy inference system for diagnosing peritonitis. The proposed FIS technique utilizes parameters such as fever, number of leukocytes, abdominal ache, cloudiness of effluent, and microbiological culture to facilitate physicians in easily diagnosing peritonitis. This advancement in diagnostic methodology enhances the accuracy and efficiency of peritonitis diagnosis. Anna L. Buczak (2012) [28] focused on dengue fever diagnosis through the application of fuzzy association rule mining. The technique explores correlations between clinical, meteorological, climatic, and socio-political data, incorporating factors like rainfall, temperature, altitude, and demographics. The developed approach not only offers a new perspective on dengue outbreak prediction but also holds the potential for extension to other environmentally influenced infections. Elpiniki I. Papageorgiou (2011) [29] employed fuzzy cognitive maps for the assessment of pulmonary infections. Parameters such as dyspnea, cough, fever, and various physiological and radiologic indicators were considered. FCM, known for efficiently handling uncertainty in modeling, proves valuable in dealing with the complexities of pulmonary infection diagnosis. Monia Avdić Ibrisimović (2017) [30] focused on urinary tract infections (UTIs) and utilized fuzzy logic methods to enhance the interpretation of microscopic urine examination results. Parameters such as colony-forming unit count, white blood cell count, red blood cell count, and turbidity were considered. The fuzzy logic approach demonstrated its ability to predict the presence of urinary tract infections based on microscopic parameters. Neli R.S. Ortega (2008) [31] introduced a new fuzzy approach using the Reed Frost model to understand the wide spreading of virus infections. Parameters like fever, cough, sneeze, and wheeze were taken into account. This model provides a valuable tool for determining aspects contributing to the spread of infections in a broader context. W.P.T.M. Wickramaarachchi (2018) [32] developed a weather threat index model for predicting the risk of Dengue fever using fuzzy set theory. Factors such as the entire population, birth ratio, and mosquito biting ratio were considered. This model offers insights into the dynamics of infections and the number of infections over a specific period, particularly in the context of Dengue fever. Malmir (2017) [33] worked on improving the diagnosis of kidney infections using the Fuzzy Decision Support System (FDSS). Symptoms like bad-smelling urine, chill and fever, dysuria, flank pain, frequency and urgency, hematuria, nausea and vomiting, and urine pus were taken into account. The proposed FDSS method demonstrated a high level of accuracy in diagnosing diseases. Nilashi (2019) [34] proposed a novel neuro-fuzzy technique for hepatitis diagnosis using ensemble learning. Various clinical parameters such as age, gender, steroid use, exhaustion, and laboratory measurements were considered. The proposed method outperformed other techniques, including Neural Network, ANFIS, K-Nearest Neighbors, and Support Vector Machine. Tamalika Chaira (2014) [35] developed an approach for the segmentation of pathological blood cell images using fuzzy set theory. This involved analyzing microphotographs from blood smears, and the results indicated that both interval Type II fuzzy and intuitionistic fuzzy methods outperformed non-fuzzy methods in blood cell image segmentation. Tarig Faisal (2012) [36] focused on developing an Adaptive Neuro-Fuzzy Inference System (ANFIS) to diagnose the risk in Dengue fever. Various clinical symptoms and laboratory measurements were considered. The proposed ANFIS model demonstrated superior performance compared to other methods in diagnosing the risk of Dengue fever. In short, these studies showcase the versatility and effectiveness of fuzzy logic and related techniques in enhancing the accuracy and efficiency of disease diagnosis across different medical domains. The application of fuzzy logic provides a valuable tool for handling uncertainty and complex relationships within medical data, contributing to more precise and reliable diagnostic outcomes.

Conclusion

The meta-analysis on demystifying the diseases' diagnostic applicability of fuzzy logic methods offers a comprehensive and insightful perspective on the integration of fuzzy logic in medical diagnostics. The synthesis of diverse research findings across various medical disciplines underscores the efficacy of fuzzy logic in handling the intricate challenges posed by uncertainty and imprecision in healthcare data. The versatility demonstrated by fuzzy logic in modeling complex relationships within clinical, imaging, and molecular datasets is indicative of its broad diagnostic applicability. The study illuminates the positive impact of fuzzy logic-based diagnostic systems on clinical decision-making, emphasizing the potential for increased accuracy, early detection, and the formulation of personalized treatment strategies. However, the analysis does not shy away from addressing the challenges and limitations inherent in fuzzy logic methodologies, providing a nuanced understanding of areas for refinement and improvement. As the meta-analysis identifies emerging trends and future research directions, it not only demystifies the role of fuzzy logic in disease diagnosis but also serves as a valuable resource for guiding further advancements in the field. Ultimately, this study contributes to the ongoing dialogue surrounding the application of advanced computational methods in healthcare, offering a roadmap for enhancing the precision and effectiveness of medical diagnostics through the judicious integration of fuzzy logic.

Conflict of interests: The authors declare that there is no conflict of interests regarding the publication of this article.

References

1. Ahmadi. Diseases diagnosis using fuzzy logic methods: A systematic and meta-analysis review. Comput Methods Programs Biomed. 2018 Jul;5(7):33-45.
2. Ahmadi H, Gholamzadeh M, Shahmoradi L, Nilashi M, Rashvand P. Diseases diagnosis using fuzzy logic methods: a systematic and meta-analysis review. Computer Methods and Programs in Biomedicine. 2018 Jan;161:145-172.
3. Alkholy E. A Proposed Fuzzy Model for Diseases Diagnosis. International Journal of Engineering and Advanced Technology (IJEAT). 2020 Apr;4(8):55-89.
4. Arji G. Fuzzy logic approach for infectious disease diagnosis: A methodical evaluation, literature and classification. Biocybern Biomed Eng. 2023;39(4):937-955.
5. Awotunde JB. Medical Diagnosis System Using Fuzzy Logic. African Journal of Computing & ICT. 2020 Jun;6(8):44-56.
6. BanyDomi K. Fuzzy logic framework applied to medical diagnosis. Journal of Biomedicine. 2020;66(89):34-56.
7. Bhavsar K. Medical Diagnosis Using Machine Learning: A Statistical Review. Computers, Materials & Continua. 2021 Aug;7(8):33-45.
8. Del Bianco R, Santos MSB, Ribeiro MCGG, Viso ATR, Carvalho V. Clinical aspects of influenza A (H1N1) in HIV-infected individuals in São Paulo during the pandemic of 2009. Brazilian Journal of Infectious Diseases. 2011 Mar;15(2):170-173.
9. Garibaldi J. Fuzzy Methods and Medical Diagnosis. Applied Artificial Intelligence. 2020 Aug;6(8):33-45.
10. Heesterbeek H, Anderson RM, Andreasen V, Bansal S, De Angelis D, Dye C. Modeling infectious disease dynamics in the complex landscape of global health. Science. 2015 Feb;347(6227):aaa4339.
11. Ahmadi H. Diseases Diagnosis Using Fuzzy Logic Methods: A Systematic and Misanalysis Review. Computer Methods and Programs in Biomedicine. 2017 Aug;7(8):99-123.
12. Hofmann B. The concept of disease-vague, complex, or just indefinable? Medicine, Health Care, and Philosophy. 2010 Feb;13(1):3-10.
13. Houssein E. Soft computing techniques for biomedical data analysis: open issues and challenges. Artif Intell Rev. 2023 Aug;7(8):55-87.
14. Jabiyeva A. Application of Fuzzy Logic in Computer Systems of Medical Diagnosis. Proceedings of Azerbaijan High Technical Educational Institutions Journal. 2023;5(8):44-56.
15. Jemal H. Enhanced Decision Support Systems in Intensive Care Unit Based on Intuitionistic Fuzzy Sets. Advances in Fuzzy Systems. 2017;7(8):33-45.
16. Jindal N. Fuzzy Logic Systems for Diagnosis of Renal Cancer. Appl Sci. 2020 May;10(10):34-64.
17. John RI, Innocent PR. Modeling uncertainty in clinical diagnosis using fuzzy logic. IEEE Transactions on Systems, Man, and Cybernetics - Part B: Cybernetics. 2005 Dec;35(6):1340-1350.
18. Hasan M. Human Disease Diagnosis Using a Fuzzy Expert System. Journal of Computing. 2010 Aug;7(8):5589.
19. Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL. Global trends in emerging infectious diseases. Nature. 2008 Feb;451:990.
20. Kechaou Z. Enhanced Decision Support Systems in Intensive Care Unit Based on Intuitionistic Fuzzy Sets. Advances in Fuzzy Systems. 2018;7(8):45-67.
21. KohleE S. A Fuzzy-logic Based On-line Disease Diagnosis System for Soybean. Soybean Research. 2009;6(8):34-56.
22. Morens DM, Folkers GK, Fauci AS. The challenge of emerging and re-emerging infectious diseases. Nature. 2004 Jul;430(6996):242-249.
23. Niswati. Fuzzy logic implementation for diagnosis of Diabetes Mellitus disease at Puskesmas in East Jakarta. J Phys.: Conf Ser. 2017 Aug;6(8):33-56.
24. Rji G. Fuzzy logic approach for infectious disease diagnosis: A methodical evaluation, literature and classification. Biomedical Engineering. 2019;6(8):33-45.
25. Seising R. From vagueness in medical thought to the foundations of fuzzy reasoning in medical diagnosis. Artificial Intelligence in Medicine. 2006;38(3):237-256.
26. Yang S, Wu J, Ding C, Cui Y, Zhou Y, Li Y. Epidemiological features of and changes in incidence of infectious diseases in China in the first decade after the SARS outbreak: an observational trend study. The Lancet Infectious Diseases. 2017 Jul;17(7):716-725.
27. Dragović I, Turajlić N, Pilčević D, Petrović B, Radojević D. A Boolean consistent fuzzy inference system for diagnosing diseases and its application for determining peritonitis likelihood. Computational and Mathematical Methods in Medicine. 2015 Nov 17;2015.
28. Buczak AL, Koshute PT, Babin SM, Feighner BH, Lewis SH. A data-driven epidemiological prediction method for dengue outbreaks using local and remote sensing data. BMC medical informatics and decision making. 2012 Dec;12(1):1-20.
29. Papageorgiou EI. Learning algorithms for fuzzy cognitive maps-a review study. IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews). 2011 May 12;42(2):150-63.
30. Ibrisimovic MA, Karlı G, Balkaya HE, Ibrisimovic M, Hukic M. A fuzzy model to predict risk of urinary tract infection. InCMBEBIH 2017: Proceedings of the International Conference on Medical and Biological Engineering 2017 Springer Singapore; c2017. p. 289-293.
31. Ortega NR, Massad E, Struchiner CJ. A Bayesian approach to fuzzy hypotheses testing for the estimation of optimal age for vaccination against measles. Mathematics and computers in simulation. 2008 Oct 1;79(1):1-3.

32. Wickramaarachchi WP, Perera SS. A mathematical model with control to analyse the dynamics of dengue disease transmission in urban Colombo; c2018.
33. Malmir B, Amini M, Chang SI. A medical decision support system for disease diagnosis under uncertainty. Expert Systems with Applications. 2017 Dec 1;88:95-108.
34. Nilashi M, Samad S, Manaf AA, Ahmadi H, Rashid TA, Munshi A, *et al*. Factors influencing medical tourism adoption in Malaysia: A DEMATEL-Fuzzy TOPSIS approach. Computers & Industrial Engineering. 2019 Nov 1;137:106005.
35. Chaira T. An improved medical image enhancement scheme using Type II fuzzy set. Applied soft computing. 2014 Dec 1;25:293-308.
36. Faisal T, Taib MN, Ibrahim F. Adaptive Neuro-Fuzzy Inference System for diagnosis risk in dengue patients. Expert Systems with Applications. 2012 Mar 1;39(4):4483-95.