

Fuzzy Expert System (FES) Integration for Oral Cancer Risk (OCR) Diagnosis

Kuljinder Kaur¹, Hari Kishan Bhardwaj², Yogendra Kumar Rajoria³, Anil Yadav⁴, Dinesh Kumar Maurya⁵, Rahul Boadh⁶,

¹National Institute of Food Technology Entrepreneurship and Management, Kundli, Sonipat, Haryana, India - 131028

²Department of Mathematics, University of Delhi, India

^{3,6}Department of Mathematics, School of Basic and Applied Sciences, K. R. Mangalam University, Gurgaon, India-122103

⁴Department of Chemical Engineering, Deenbandhu Chhotu Ram University of Science and Technology, Murthal, Sonipat, Haryana, India - 131027

⁵Department of Mathematics, Faculty of Science & Technology M.G. Kashi Vidyapith, Varanasi-221002

*Corresponding Author: Dr. Rahul Boadh (Assistant Professor), Email: rboadh.iitkgp@gmail.com

⁶Department of Mathematics, SBAS, K. R. Mangalam University Sohna Road Gurugram, Haryana, India-122103

Doi: 10.47750/pnr.2022.13.508.421

Abstract

Because the malignancy system has been poorly planned thus far, oxidative pressure has been emphatically linked to carcinogenesis. The Fuzzy Expert System (FES) was used in this study to assess the oxidative pressure-related cancer risk of potentially life-threatening oral disorders. The serum data of twenty patients with potentially malignant oral disorders were used for this purpose. This data was fed into FES, which generated the 20 rules based on the knowledge system. Following that, the risk of Oral Cancer (OC) was assessed on a scale of 0 to 100. Following a thorough examination, this study advocates that the current methodology might be castoff as a primary assistance in OC transmission and to create upcoming health decisions in hypothetically malicious oral tissues.

Keywords: FES, Oral Cancer, Matlab2104a, Risk Factor

1. INTRODUCTION

In India, most of the workers are using tobacco pan masala it is main source of the OCR. Over Eastern Europe (EU) has a high incidence of OC, which is the seventh most common cancer in the EU [1]. Squamous cell carcinomas account for more than 80% of mouth malignancies and are caused by oral potentially malignant conditions [2]. Although carcinogenesis has been extensively studied in recent decades, its prognostic accuracy has not improved [3]. Therefore, the therapy of this disease could perhaps be improved by their initial analysis, effective transmission, besides calculation of the cancerization hazard. Large amounts of information are necessary for any choice.

Different patients may experience the condition in varying degrees of intensity. Certain statistics have uncertainties, the majority of which are provided by the patients. A clinician would find it challenging to analyse such a large amount of data; thus, it would be computerized and used wisely. Conservative algebraic techniques remained used, although they are time-consuming and not appropriate in every situation [4]. Following revelation to hazards, an extensive series of metabolic variations, epigenetic and genomic take place during carcinogenesis, and many components are involved [5]. The term "fuzzy" set, which was first used in 1965, refers to a subset of fuzzy logic that is utilised in mathematics and systems theory. A fuzzy set represents an entirely different approach to the traditional understanding of set and its components, wherein an presence is whichever one of the set's components or not. More specifically, there is a wide variety of transient, continuous situations between the elements' membership and non-membership that are distinguished by values that represent their varying degrees of membership [6,7]. In its most basic form, fuzzy logic stretches the true/false dichotomy to encompass a variety of notches of fact responses in between. The FL, which introduces partial truths, is more applicable in medicine, since diagnosis necessitates complicated data with multiple levels of uncertainty and imprecision [8, 9].

Artificial intelligence (AI)-based prediction is a compelling alternative to the current prediction technologies. This methodology, known as machine learning, is based on the capacity for pattern recognition and generalisation that is similar to that of humans. Machine learning algorithms developed and applied by researchers have shown to be quite useful. Many studies advocate the usage of AI in treatment, complete a focus on cancer in particular. Most of them recognise, categorise, find, or discriminate tumours, whereas only a handful forecast or diagnose cancer [10-12], FES is also used with different authors for diagnoses the cancer and other health issues [13-17]. Other applications of FL are used for solve other problem in stock market and health care [18, 19]. Being able to introduce language words that are simpler for human users to grasp and communicate with into the decision-making process using this machine algorithm is a significant benefit that can stand alone as a justification for using fuzzy logic in medicine [20, 21]. The Neuro-Fuzzy is also used to solve industrial related problem [26]. Many authors have used the mathematical modelling in different

sector [27-36]. Keeping all the things in mind this study tries to integrate the FES in MATLAB2014a for diagnosis the OCR.

2. DATA AND METHODOLOGY

For this study, the 20 patients' data have been used form Prabhat hospital in Gurugram city, Haryana. A sample of venous blood (5 ml) was taken, then it was instantly centrifugated at a speed of 3500 rpm. After processing, the resultant serum was frozen and stored until two biological variables were determined. For this study, two type of data has been used for generating the FIS knowledge base.

The roles are as follows:

- i. DONORS PROTONS (DP) (30.5000; 58.2000) [inhabitation in percentage]
- ii. MDA (1.2000; 12.000) (nmol/ml) (Based on previous studies).

Both data collected based on the previous studies. The input and output parameter has been shown in Fig. 1. The measured standards of the blood serum variales (MDA and DP, correspondingly) in individuals with possibly malignant conditions of the mouth were used to determine the intervals. We developed membership functions to translate the numerical data of the inputs to the linguistic terms (LT), and introduced LT into the decision-making process:

- iii. Determining the LT connected to each input value.

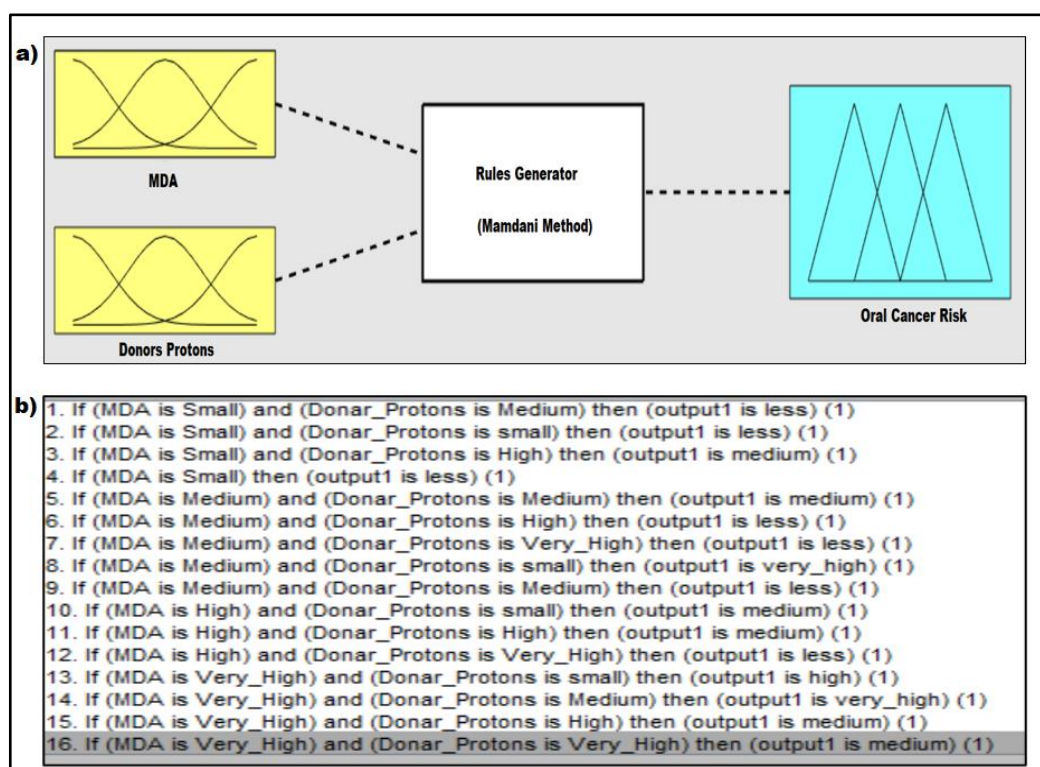


Fig. 1: (a) Input and output parameter of FIS, (b) FIS rules based on the IF-THEN combination

In order to evaluate the values in the input data and assign values to the output based on a set of rules, we used FIS. The multi-standards knowledge base system used to calculate OCR was put into practise using the methods below. Using the MATLAB2014a tool, fuzzy logic has been used for health care and risk analysis [22]. As a fuzzy association between knowledge about the state of the cycle to be controlled and the control action, fuzzy logic control addresses the estimation for measure control. An unexpected statement between a fuzzy input parameter X and a fuzzy output parameter Y is the encapsulation of fuzzy control estimations. An explanation of the phonetic ramifications, such as X implies Y, is used to express this (X condition denotes condition B). This might be expressed as IF X THEN Y. This verbalization is equivalent to the association obtained from Cartesian expansion, such as $R=X \times Y$, IF X THEN Y.

The output values are also in LT association. For fuzzy rule generated by the using Mamdani Method (Fig. 1a). To contest the several LT then produce the outputs, a total of 16 knowledge base rules are developed. The IF-THEN rule states that the risk of acquiring cancer is increased IF MDA is increased and DP is decreased (Fig. 1b). Before any investigation was carried out, all of the patients provided their informed consent.

3. RESULTS AND DISCUSSION

The MDA and DP input numerical values were introduced into the system during the deployment of the multi-standards knowledge decision base system, which led to the calculation the risk of OC in the term of numerical value. If-then rules were used to map the relationship between inputs and outputs: if MDA is up and DP is lowered, the risk of cancer is

raised. We formulated the guidelines because oral cancer patients had higher blood oxidative stress and lower serum total antioxidant capacity than people with potentially malignant diseases of the mouth [23-25].

The OCR has been computed for the various scenarios after constructing the fuzzy rules. If the patient's MDA of 9 nmol/ml and the 20% inhibition of DP are taken into account, the OCR is high (70.7%) as shown in Fig. 2a. It is abundantly obvious that if MDA is high and DP is low, there is a substantial risk of OC; other study has shown comparable findings [26]. When DP is strong (58 percent inhibition) and MDA is low (2 nmol/ml) (Fig. 2b), the risk factor for oral cancer is lower (26.3%), according to another study conducted in Iran [26].

By taking into account various LT of MDA and DP, we estimated the OCR for 100 examples in Table 1. The highest OCR value is correlated with the maximum charge of MDA and the deepest charge of DP in the difference pitches. The lowest MDA charge corresponding to the largest DP value also has the lowest OCR value (Table 1). The system creates a risk value for each value in the variation fields (Table 1).

On a scale of 1 to 100, the risk of developing cancer has a value of 43.80% when MDA is measured small (1.50 nmol/ml) has shown in Table 1, and DP measured low value of 36.50 inhibition percent, then OC risk is slightly medium. This study has considered nearly hundred cases in different condition for calculate the OCR. It has observed that if MDA is high and DP is less then OCR is high.

The three-dimension diagram of LT of OCR has shown in Fig. 3. A result of the output value's dependence on the input values. Red represents a higher level of OCR than blue due to increasing MDA and decreased DP, which are both indicated by the colour. The OCR varies to less to high when MDA varies from less to high and DP is varying high to low.

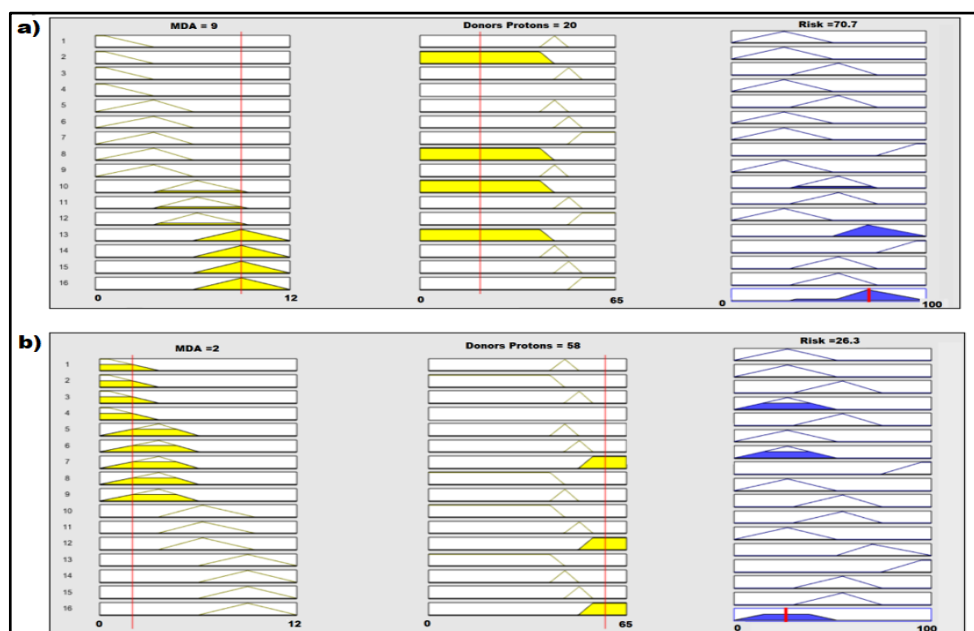


Fig. 2: (a) Analysis of OCR at MDA=9 (nmol/ml) and DP =20 (inhibition %), (b) Analysis of OCR at MDA=2 (nmol/ml) and DP =58 (inhibition %)

Table 1: Risk assessment with different input parameters

S.N.	MDA (nmol/ml)	DP (inhibition %)	OCR (%)
1	1.50	36.50	43.80
2	2.10	38.50	50.30
3	2.54	57.50	26.40
4	3.50	32.00	85.70
5	3.90	33.67	81.50
6	4.30	40.60	66.00
---	-----	-----	-----
56	6.80	52.60	34.10
57	8.62	20.00	68.40
58	9.60	39.89	74.20
---	-----	-----	-----
84	11.00	38.50	75.10
---	-----	-----	-----
99	2.11	58.64	26.37
100	1.63	62.50	26.40

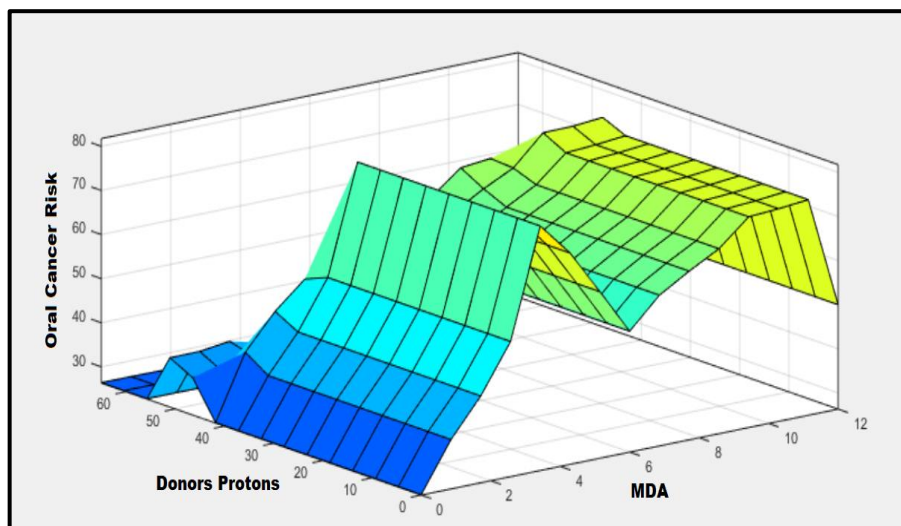


Fig. 3: Three-dimension representation of OCR

It is clearly seen in this figure when MDA is 1 nmol/ml and DP is 56 % of inhibition then OCR is nearby 25% that is similar to the other study done in Iran [26]. After integrating many cases with different condition this study can suggest that if MDA is less and DP is high then risk factor of OCR is less. A result of the output value's dependence on the input values.

4. CONCLUSION

This study, suggest using FES in the current experiment to assess the risk of oral cancer associated with oxidative stress. A Knowledge base decision making care arrangement that could use information provided input from the user's, provide a response has been developed by us (output). FES in specific offers the benefit of permitting the routine of confusing principles as input information untrustworthy towards further procedures, as well as promoting a relationship between the illness parameters' numerical values and linguistic phrases, calmer for the user to procedure. A more advanced computerised decision support system can incorporate the knowledge base decision-making assistance system that we have proposed. We believe that a computer system with an intuitive user interface that estimates the CR of oral potentially malignant disorders using initial and/or sole minimally bellicose selection (fluid or saliva) indicators can be a significant clinicians' aid in screening and making future medical decisions. This study advocate that this algorithm may be used by doctors for better diagnosis the OCR and it could be modified with using hybrid techniques with other modelling system.

DATA AVAILABILITY:

Data will provide when it will be required.

Conflict of interest /Disclosure Statement:

There were no conflicts of interest revealed by the authors.

REFERENCES

- Warnakulasuriya S (2009). Global epidemiology of oral and oropharyngeal cancer. *Oral Oncol*, 45 (4-5): 309–16. <https://doi.org/10.1016/j.oraloncology.2008.06.002>
- Llewellyn CD, Johnson NW, Warnakulasuriya KAAS (2001). Risk factors for squamous cell carcinoma of the oral cavity in young people: a comprehensive literature review. *Oral Oncol*, 37 (5): 401–18. [https://doi.org/10.1016/S1368-8375\(00\)00135-4](https://doi.org/10.1016/S1368-8375(00)00135-4)
- Ferlay J, Soerjomataram I, Dikshit R, et al (2015). Cancer incidence and mortality worldwide: Sources, methods and major patterns in GLOBOCAN 2012. *Int J Cancer*, 136 (5): E359–86. <https://doi.org/10.1002/ijc.29210>
- Latha KC, Madhu B, Ayesha S, et al (2013). Visualization of risk in breast cancer using fuzzy logic in matlab environment. *Int J Comput Intell Tech*, 4 (1): 114-7. Available online at <http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000221>
- Lippman SM, Hong W.K (2001). Molecular Markers of the Risk of Oral Cancer. *N Engl J Med*, 344 (17): 1323-6. DOI: 10.1056/NEJM200104263441710
- Zadeh LA (1965). Fuzzy sets. *Inf Control*, 8(3): 338–53. Available online at [Zadeh - Fuzzy sets.pdf \(tsilikin.ru\)](http://www.fuzzy-sets.com/).
- Zadeh LA (1996). Fuzzy Logic = Computing with Words. *IEEE Trans Fuzzy Syst*, 4 (2): 103-11. https://doi.org/10.1142/9789814261302_0021
- Abbod MF, von Keyserlingk DG, et al (2001). Survey of utilisation of fuzzy technology in Medicine and Healthcare. *Fuzzy Set System*, 120 (2): 331–49. [https://doi.org/10.1016/S0165-0114\(99\)00148-7](https://doi.org/10.1016/S0165-0114(99)00148-7)
- Latha KC, Madhu B, Ayesha S, et al (2013). Visualization of risk in breast cancer using fuzzy logic in matlab environment. *Int J Comput Intell Tech*, 4 (1): 114-7.
- Available online at <http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000221>
- Cruz JA, Wishart DS (2007). Applications of machine learning in cancer prediction and prognosis. *Cancer Informatics*, 2: 59–77. <https://doi.org/10.1177/117693510600200030>
- Doi K (2007). Computer-aided diagnosis in medical imaging: historical review, current status and future potential. *Computerized Medical Imaging and Graphics*, 31 (4-5): 198-211. <https://doi.org/10.1016/j.compmedimag.2007.02.002>
- Kourou K, Exarchos TP, Exarchos KP, et al (2015). Machine learning applications in cancer prognosis and prediction. *Comput Struct Biotechnol J*, 13: 8–17.

14. G. Karla, R. Boadh, Y.K. Rajoria, P. Rajendra, Prediction and Analysis of Health Risk by using Fuzzy Control System, *International Journal of Health Sciences (IJHS)*, 2022a, Vol. 6(S2), pp. 7511–7524. <https://doi.org/10.53730/ijhs.v6nS2.6808>.
15. G. Karla, R. Boadh, Y.K. Rajoria, P. Rajendra, N. Khatak, A.Kumar, Study of fuzzy expert systems towards prediction and detection of fraud case in health care insurance, *Materials Today: Proceedings*, 2022b, vol. 56 (1), pp 477–480. doi: <https://doi.org/10.1016/j.matpr.2022.02.157>.
16. R. Boadh, D.D. Aarya, M. Dahiya, R. Ratheed, S. Rathee, A. Kumar, S. Jaing, Y.K. Rajoria, Study and Prediction of Prostate Cancer Using Fuzzy Inference System, *Materials Today: Proceedings*, 2022a, 157-164. <https://doi.org/10.1016/j.matpr.2022.01.040>.
17. R. Boadh, R. Grover, M. Dahiya, A. Kumar, R. Rathee, Y.K. Rajoria, M. Rawat, S. Rani, Study of Fuzzy Expert System for the Diagnosis of Various Types of Cancer, *Materials Today: Proceedings*, 2022b, 298-307. <https://doi.org/10.1016/j.matpr.2022.01.161>.
18. R. Boadh, K. Chaudhary, M. Dahiya, N. Dogra, S. Rathee, A. Kumar, Y.K. Rajoria, Analysis and Investigation of Fuzzy Expert System for Predicting the Child Anaemia, *Materials Today: Proceedings*, 2022c, 231-236. <https://doi.org/10.1016/j.matpr.2022.01.094>.
19. Poswal, P., Chauhan, A., Rajoria, Y. K., Boadh, R., & Singh, A. P. (2022a). An economic ordering policy to control deteriorating medicinal products of uncertain demand with trade credit for healthcare industries. *International Journal of Health Sciences*, 6(S2), 9392– 9414. <https://doi.org/10.53730/ijhs.v6nS2.7460>.
20. Poswal, P., et al. Investigation and analysis of fuzzy EOQ model for price sensitive and stock dependent demand under shortages, *Materials Today: Proceedings*, 2022b, <https://doi.org/10.1016/j.matpr.2022.02.273>.
21. Castellano G, Castellano C, Fanelli A (2005). Knowledge discovery by a neuro-fuzzy modeling framework. *Fuzzy Set Syst*, 149 (1): 187– 207. <https://doi.org/10.1016/j.fss.2004.07.015>
22. Zadeh LA (1975). The concept of linguistic variable and its applications to approximate reasoning-II. *Inform Sci*, 8 (4): 301–57. [https://doi.org/10.1016/0020-0255\(75\)90046-8](https://doi.org/10.1016/0020-0255(75)90046-8)
23. Mayilvaganan M, Rajeswari K., 2014, Health Care Analysis Based on Fuzzy Logic Control System. *International Journal of Computer Science Trends and Technology*, 2(4):119-122. Available online at <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.677.6621&rep=rep1&type=pdf>
24. Zheng W, Blot WJ, Diamond EL, et al (1993). Serum Micronutrients and the Subsequent Risk of Oral and Pharyngeal Cancer. *Cancer Res*, 53 (4): 795-8. 29. Available online at <https://aacrjournals.org/cancerres/article/53/4/795/499556/Serum-Micronutrients-and-the-Subsequent-Risk-of>
25. Salzman R, Pácal L, Tomandl J, et al (2009). Elevated malondialdehyde correlates with the extent of primary tumor and predicts poor prognosis of oropharyngeal cancer. *Anticancer Res*, 29 (10): 4227-31. 30. Available online at <https://ar.iiarjournals.org/content/29/10/4227.short>
26. Korde SD, Basak A, Chaudhary M, et al (2011). Enhanced nitrosative and oxidative stress with decreased total antioxidant capacity in patients with oral precancer and oral squamous cell carcinoma. *Oncology*, 80 (5-6): 382-9. <https://doi.org/10.1159/000329811>
27. Scrobotă, I., Grigore, B., Adriana, GF., Bianca, T., Florin, B., Mihaela, FB. (2017). Application of Fuzzy Logic in Oral Cancer Risk Assessment, *Iran Journal of Public Health*, 46 (5), pp.612-619. Available online at <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5442273/pdf/IJPH-46-612.pdf>
28. Kalra G., Kishor, K., Kumar, A., Rajoria, Y. K., Yadav, A., and Boadh, R. (2022a). FIS-Based Prediction and Estimation of Health Insurance for Workers in the Manufacturing Sector, *Journal of Pharmaceutical Negative Results*. Vol. 13 (S8), pp. 2236-2245. DOI: 10.47750/pnr.2022.13.S08.331.
29. Bhagat, R. K., Yadav, A., Rajoria, Y. K., Raj, S. and Boadh, (2022). Study of Fuzzy and Artificial Neural Network (ANN) Based Techniques to Diagnose Heart Disease, *Journal of Pharmaceutical Negative Results*. Vol. 13 (S5), pp. 1023-1029. Doi: 10.47750/pnr.2022.13.S05.161.
30. Poswal, P., Chauhan, A., Aarya, D. D., Boadh, R., Rajoria, Y. K. and Gaiola, S. U. (2022a). Optimal Strategy for Remanufacturing System of Sustainable Products with Trade credit under Uncertain Scenario, *Materials Today: Proceedings*. <https://doi.org/10.1016/j.matpr.2022.08.303>.
31. Boadh, R., Yadav, S. N., Tiwari, A., Rajoria, Y. K. and Singh, J. (2022a). Application of fuzzy inference system (FIS) for assessment and predication of compressive asset of concrete containing fly ash, *Materials Today: Proceedings*. <https://doi.org/10.1016/j.matpr.2022.08.160>.
32. Poswal P, Chauhan A, Boadh R and Rajoria Y.K (2022b). A review on fuzzy economic order quantity model under shortage, *AIP Proceeding*, 2481, 040023(1-13) 10.1063/5.0103757.
33. Poswal, P., Chauhan, A., Rajoria, Y. K., Boadh, R. and Goel, A. (2022d). Fuzzy optimization model of two parameter weibull deteriorating rate with quadratic demand and variable holding cost under allowable shortages, *Yugoslav Journal of Operations Research*, Vol.32 (4).
34. Neelofar, Rajoria, Y. K., Alsarairoh, I. and Boadh, R. (2022). The Initial Investigation of Mathematical Anxiety & Phobia: It's Solution in Middle School Students, *Journal of Positive School Psychology*. 2022, Vol. 6(6), pp. 8323-8328.
35. Aarya, D. D., Prakash, S., Boadh, R., Chauhan, A., and Rajoria, Y. K. (2022). The Implementation of the Pentagonal Fuzzy Number toward the Solution of the Fuzzy Inventory Model with Ramp Demand Function and Three Parameters Weibull Deterioration, *Neuroquantology*, Vol. 20 (17), pp. 117-126. Doi: 10.14704/Nq.2022.20.17.Nq88017.
36. Mangla S., Sharma, S., Boadh, R. and Rajoria, Y. K. (2022). A Mathematical Model of the Impact of Deforestation on the Growth of Forest Resources, *Neuroquantology*, Vol. 20 (17), pp. 223-226. Doi: 10.14704/Nq.2022.20.17.Nq88030.
37. Rajoria, Y. K., Saini, S., & Singh, S. R. (2015). EOQ Model For Decaying Items With Power Demand, Partial Backlogging and Inflation. *International Journal of Applied Engineering Research*, 10(9), 22861-22873.