



Covid-19 Risk Model Development Using Fuzzy Logic For The Reopening Of Face-To-Face Classes

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ABSTRACT

COVID-19 pandemic had caused a global crisis in the education sector due to the urgent closure of schools to prevent the spread of the virus. After so much effort to curb the transmission of Coronavirus, the Philippine government has finally approved the re-opening of face-to-face classes in colleges and universities. However, responding to educational needs might pose COVID risks to the academic community. Thus, this study used the Fuzzy Logic to develop a model to measure the risk associated with COVID under the Northeastern Mindanao State University – Tagbina campus condition. Results showed that developed model using Fuzzy Logic algorithm produced satisfying result after expert validation in assessing Covid-19 risk transmission. Further, using the developed model, the campus has 38.5% risk, classified as "Low". Despite challenges in opinions of multiple experts, the model was able to draw conclusion in support to campus management's decision-making pertaining to campus risk of covid transmission.

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1. INTRODUCTION

The COVID-19 pandemic has a negative impact on the economic, health, tourist sectors specially in the country's education system. As a result, education around the world are experiencing numerous difficulties and most of the people who are affected directly are the students. As a preventative step against the rapid spread of viral infection, authorities in various nations throughout the world have implemented lockdown or curfew orders. The urgency to slow the spread of the virus led to closures of schools across the country, with little time to ensure continuity of instruction or to create a framework for deciding when and how to reopen schools (NAS, 2020). As stated by Agaton et al. (2021) learners and their parents faced a variety of hurdles as a result of the abrupt move in education from the classroom to home schooling including educational, economic and technical issues. The Universities and Colleges in the Philippines had been closed since the start of COVID-19 pandemic.

According to UNESCO (2020) and Romero et al. (2021), more than 100 countries have closed their schools due to the COVID-19 pandemic, affecting millions of students. As stated by Naciri (2020), thousands of Universities and colleges worldwide have closed their doors to encourage social distancing measures to avoid contracting the virus. With one of the longest school breaks in history, the Philippine government has finally approved the phased rollout of face-to-face classes for Colleges and Universities beginning in November 2021. Fauci (2020) mentioned that returning to school will be an experiment that suggests that the results are unknown. Therefore, health protocols must be carefully deliberated concerning national and international guidelines, as it is the country's responsibility to develop strategies to re-open classes (Sarmiento et al., 2021).

The decision to re-open is based on guidance documents provided by the Commission on Higher Education. Universities and Colleges may apply to conduct limited face-to-face classes beginning December 2021 and onwards. While this is not mandatory, it leaves the University management with tremendous responsibility for making a judgment about the risk of re-opening while also responding to the needs of students, faculty, and staff. As stated in the general health and safety protocols, encourage the use and practice of respiratory etiquette and other preventive measures following the DOH guidelines on risk-based public health standards for COVID-19 mitigation. In addition, all students, teachers, and non-teaching staff must follow these general health safety rules by using protective equipment. In addition, the school must guarantee that disinfection supplies are available at all times (Singh-Vergeire, 2020).

The North Eastern Mindanao State University applied for authorization to conduct limited face-to-face classes with this provision. When classes resume, the university must closely adhere to school health regulations to guarantee the safety of students, teachers, and staff. The World Health Organization also issued a checklist to help re-open and prepare for COVID-19's resurgence. Thus, it is very important to develop a model that will measure the risk of the campus in a given environment. The developed model will serve as the decision support tool and will be the basis for maintaining a low risk of COVID-19 transmission during the re-opening of limited face-to-face classes on the campus.

2. RESEARCH METHOD

The researchers utilized the Fuzzy Logic model in risk assessment of limited face-to-face classes under the NEMSU-Tagbina campus condition. Fuzzy logic uses a mathematical representation of fuzziness based on terms or logic that extends the range of truth values to all real numbers in the interval between zero (0) and one (1) (Lukasiewicz, 1930). It is determined as a set of mathematical principles for knowledge representation based on degrees of membership rather than on crisp membership of classical binary logic (Zadeh, 1965). Figure 1 below shows the Fuzzy Inference System of COVID-19 Risk given the identified factors using the Mamdani Style Inference.

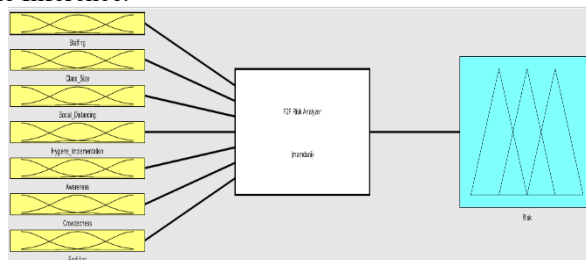


Figure 1. Fuzzy Inference System of COVID-19 Risk

The following algorithm was used in the development of COVID-19 pandemic risk assessment model. See Figure 2 below:

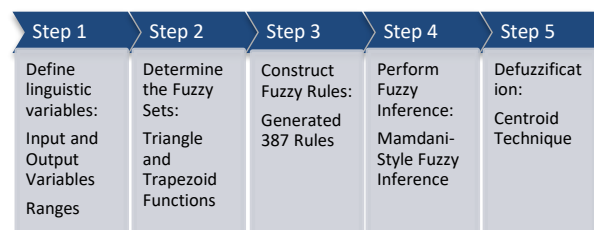


Figure 2. Fuzzy Logic Algorithm

2.1. Population and Samples

Since the study method is model development, the researchers used multiple experts in the field, specifically the local Inter-Agency Task Force (IATF) for Covid-19 Pandemic Response and the task force counterpart of the university's management and administration. Purposive sampling was applied in this study.

2.2. Research Instrument

Following the Fuzzy Logic model, two (2) qualitative instruments were used in data acquisition. First is the interview of IATF using the structured interview guide, which aimed to determine whether certain values belong to a certain set. The output of these instruments allowed the researchers to produce fuzzy sets and rules (Zadeh, 1965). Second is the initial assessment of the independent variables under the university condition using observed behavior and literature.

2.3. Collection of Data

The researchers conducted an individual interview with the IATF. The expert is asked for their expert opinion on whether various elements belong to a given set. For example, after acquiring the knowledge for the campus' facilities, the researchers could produce fuzzy sets of excellent, moderate, and poor ventilation. The others mustn't influence one expert's opinion.

2.4. Data Analysis

The researchers used the Fuzzy Logic Designer of Matlab software. Using this modeling software, fuzzy sets were generated using triangle and trapezoid functions. The researchers maintain sufficient overlap in adjacent fuzzy sets for the fuzzy system to respond smoothly. Using these fuzzy sets, fuzzy rules were generated. Once the fuzzy rules were completed, encoding them to the fuzzy inference, in this case, the Mamdani-style inference, is necessary (Mamdani & Assilian, 1975). Finally, is the defuzzification process uses the centroid technique to complete the model development.

3. RESULTS AND DISCUSSION

The model was developed following the fuzzy logic method and generated three-hundred eighty-seven (387) rules. A three-dimensional plot for two-input and one-output system was used to evaluate and tune the model. Since we have multiple input variables in this study, the researchers generated 3-dimensional output surfaces by varying any of two input variables and keeping the other input constant. Figure 2 depicts the three varying 3-dimensional plots of COVID-19 Risks associated with the constant input variable Class_Size and the varying input variables Social_Distancing, Facilities, and Hygiene_Implementation.

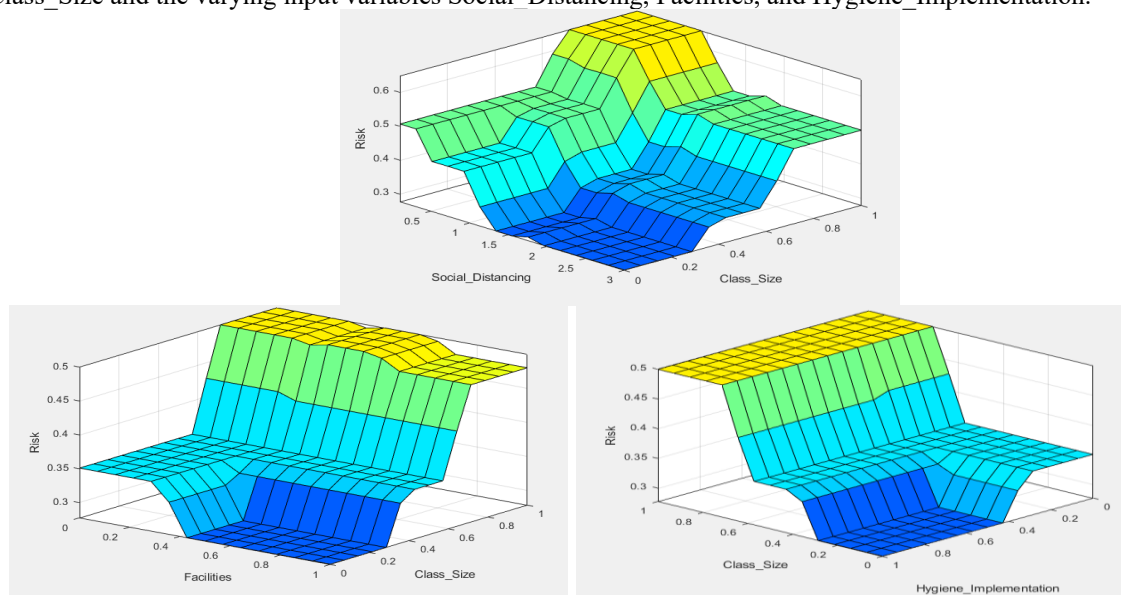


Figure 3. Three-Dimensional Plots of 2-Input 1-Output System

Figure 3 (a) depicts very low risk when Social_Distancing is maintained excellent while the Class size is maintained small. Notably in Figure 3 (b), larger Class size, regardless of the Facilities, would result to High or Very High Risk. Similarly, Figure 3 (c) shows high or very high risk when Class size is large despite too strict in Hygiene Implementation.

The values of the input variables are shown in Table 1 based on the current situation of the NEMSU-Tagbina Campus. Data from the expert, observed behaviors, and surveys were used to assign values to the items. This set of data relevant to the campus will be fed into the developed model to calculate the risk value associated with the resumption of face-to-face classes on campus. The values of input variables were

normalized (ranges from 0 to 1) except Social Distancing, which uses meter as a unit of measurement. Among seven (7) input variables, five (5) of them initially resulted in low risk while the other two variables resulted in moderate and High.

Table 1. Risk Assessment under NEMSU-Tagbina Condition

Input Variables	Numerical Value	Linguistic Value	Risk
Staffing	0.40	Fair	Moderate
Class Size	0.50	Medium	High
Social Distancing	1.20	Good	Low
Hygiene Implementation	0.90	Too Strict	Low
Awareness	0.70	Moderately Aware	Low
Crowdedness	0.40	Desirable	Low
Facilities	0.65	Excellent Ventilation	Low

Using the Centroid method of defuzzification, the researchers could produce crisp output of Covid-19 risk in the campus. Calculating the Center of Gravity (COG) based on the numerical value in Table 1, Figure 4 below shows 0.385 or 38.5% risks.

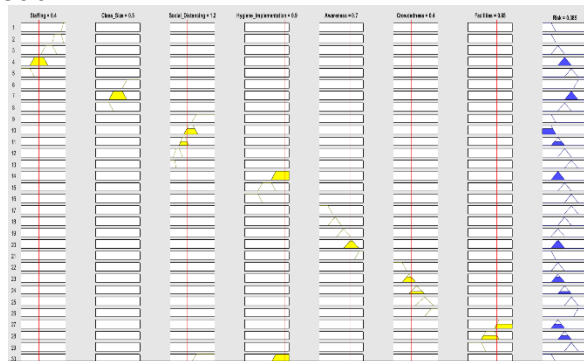


Figure 4. Covid-19 Risk Assessment Result of the Campus

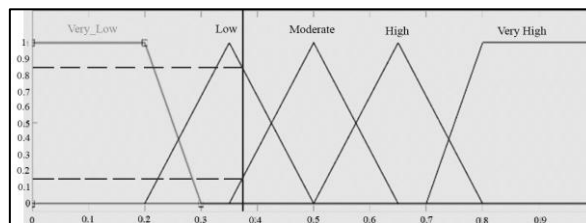


Figure 5. Degree of Membership of Risk Value

Figure 5, on the other hand, shows the degree of membership of risk value of 38.5 percent. The concept of fuzzy logic is that each value belongs to a certain set with some degree of membership. In this case, the risk value 38.5 percent belongs to set Low with a degree of membership of 0.85 and Moderate risk with the degree of membership of 0.15.

3.2 Discussion

The developed model produced a satisfying result after the experts in the field validated them. Given the multiple variables in calculating the Covid-19 risk, the fuzzy logic designer provided easy interpretations through its integrated graphical editors that will aid the decision support of the campus administration making the developed model through the Fuzzy Logic Designer more flexible. This conforms to the study of Kazanasmaz (2013) which states that a fuzzy inference system (FIS) constructs a model that helps to categorize the complexity of real-world tasks into simple units. Because of its flexibility, the model allows the campus management to update the numerical values of all variables to update Covid-19 risks. This way, it is easy to foresee when a certain environment is going critical risk. However, challenges were met during selecting the generated rules and assigning weight values, as in the case of multiple experts, would have different opinions in this matter. The same challenge is observed in Podofillini et al. (2010) study, where

validation of the dependence model against empirical data is significantly challenging due to the difficulty of collecting failure probability data but is still expected to draw some conclusions on the model face validity.

During the Covid-19 pandemic, all public (State and Local Universities and Colleges) and private HEIs and their campuses are abiding to and following CHED-DOH Joint Memorandum Circular (JMC) No. 2021-001 on the gradual re-opening of campus for limited face-to-face classes (CHED, 2021). In NEMSU-Tagbina Campus settings, strict implementation is administered and results in 38.5 percent risk linked with the Covid-19 pandemic. The components of social distancing and class size, which had good and medium linguistic qualities, respectively, resulted in "Low to Moderate" risk. Nurrunabi and colleagues (Nurrunabi et al., 2021) argue that social distance and behaviors promoting appropriate hygiene and sanitation should be enforced to mitigate health risks. Online and remote work-based learning should be improved and, when possible, scaled up. When schools re-open, they should address the concerns of fulfilling the needs of varied learners and the obstacles that develop as a result of the closures. It can be seen from the relationship between factor class size and the facilities associated with covid-19 danger, for instance, that factor class sizes of 80 percent or above, regardless of the values in Facilities result in threat levels ranging from "High to Extremely High." According to the risk assessment, given the 50 percent class size and the 0.65 numerical value of the campus facility, the risk is deemed to be "Low" under the existing campus conditions. The fact that students have direct contact with other people in schools and facilities is not the main reason for this, however, according to the findings of Brockmann (2020).

Concerning covid-19 risk, class size and hygiene implementation are important factors to consider. To attain "Very Low" and "Low" risk levels, the plot suggests that class sizes should not exceed 50% of the total student population and that hygiene should be strongly enforced. Given the 50 percent class size and a numerical value of 0.90 for hygiene implementation on campus, the risk is considered to be minimal. Improved hygiene and social distancing measures and a specific class size policy can all help reduce the frequency and severity of illnesses. Hygiene precautions are also important because they reduce the likelihood of transmission in the event of contact, as indicated by the Dalton et al. (2020) study.

The developed model is flexible in a way that it measures covid-19 risk despite changing conditions of the campus. The model is a great decision-support tool that allows campus administration to implement certain modalities and policies without posing high covid-19 risks to the academic community. Based on the overall risk generated by the model considering all factors, the campus can implement the limited face-to-face class with strict monitoring on social distancing and hygiene implementation. The model could be useful to other schools that wants to resume face-to-face classes.

3.3 Suggestions

The input variables in this study do not include the vaccination status of employees and students of the campus. Thus, it is suggested to tune up the model by adding this variable. It is also suggested to develop a model from a single expert and compare the reliability of both models. Finally, the study on risk assessment, especially on Covid-19 transmission, would be an interesting area for other models to explore, such as neural networks and complex adaptive systems.

4. CONCLUSION

The developed model is flexible in a way that it measures covid-19 risk despite changing conditions of the campus. The model is a great decision-support tool that allows campus administration to implement certain modalities and policies without posing high covid-19 risks to the academic community. Based on the overall risk generated by the model considering all factors, the campus can implement the limited face-to-face class with strict monitoring on social distancing and hygiene implementation.

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