



## ACKNOWLEDGEMENTS

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## TABLE OF CONTENTS

<b>ACKNOWLEDGEMENTS</b>	<b>ii</b>
<b>TABLE OF CONTENTS</b>	<b>iii</b>
<b>LIST OF FIGURES</b>	<b>v</b>
<b>LIST OF TABLES</b>	<b>vi</b>
<b>ABSTRACT</b>	<b>vii</b>
<b>1 INTRODUCTION</b>	<b>1</b>
1.1 Research Backgroud	1
1.2 Problem Statement	3
1.3 Research Objectives	3
1.4 Significant of Project	3
1.5 Scope of Project	4
<b>2 LITERATURE REVIEW</b>	<b>5</b>
2.1 History of Fuzzy and Neutrosophic Sets	5
2.2 Cognitive Maps	6
2.3 Fuzzy Cognitive Maps (FCMs)	7
2.4 Neutrosophic Cognitive Maps (NCMs)	9
2.5 Coronavirus Disease 2019 (COVID-19)	10
<b>3 PRELIMINARIES</b>	<b>15</b>
3.1 Algorithm 1: Fuzzy Cognitive Maps (FCMs)	15
3.2 Algorithm 2: Neutrosophic Cognitive Maps (NCMs)	16
<b>4 METHODOLOGY</b>	<b>19</b>

## ABSTRACT

After several years of the spread of coronavirus disease 2019 (COVID-19) around the world occurred World Health Organization (WHO) has stimulated great efforts to develop a vaccine against the COVID-19. Therefore, all of citizen is obliged to take the vaccine for precaution. However, the vaccine is only one step to reduce the spread of COVID-19, where the appearance of COVID-19 can occur after vaccination. Some of people do not understand the vaccine function where it is used to prevent spreading COVID-19. This research is analysed the emergence of COVID-19 post-vaccination by using the method of Fuzzy Cognitive Maps (FCMs) and Neutrosophic Cognitive Maps (NCMs). Both methods are suitable to apply in medical diagnosis since it involves uncertainty and indeterminacy. These methods of FCMs and NCMs involved eight steps included with the step of comparison to achieve the objectives. The collected data from an interview with two experts called as a concept and from there the directed graph and adjacency matrix are constructed. Multiplication between vectors and matrices are repeated until the fixed point in finding the hidden pattern for all the concepts for COVID-19 post-vaccination obtained. The results obtained by the first expert for both methods gives four different results with different value in limit cycle but method of NCMs gives better in analysis of the emergence of COVID-19 post- vaccination because it was found that there is an indeterminant factor in NCMs which is the concept of  $C_4$  where people having high blood pressure, diabetes, tuberculosis, elder people who are violating  $C_3$ . The both methods of FCMs and NCMs in second expert showed the same result which is '1' shows the persons having all the factor are have the possibility and high risk of getting COVID-19. The method of NCMs cannot applied in second expert's data since it did not show the relation of indeterminacy between two concepts.

# 1 INTRODUCTION

## 1.1 Research Background

Several mathematical tools have been developed to simulate and address real-world situations especially in the medical field. In medical diagnosis, a fuzzy set (FS) introduced by Zadeh (1996) is usually used since that method is suitable in analyzing information that is related to imprecision, vagueness, and uncertainty. FS have a degree of membership function in the interval  $[0,1]$ . In fact, an entity in FS of the degree of non-membership still cannot solve a few problems. Later on, Smarandache et al. (1999) introduced the concept of Neutrosophic set (NS) since FS cannot handle the indeterminacy of information. A neutrosophic set has a truth membership function, indeterminate membership function and false membership function respectively.

In this study, some concepts in the medical term are uncertainty and indeterminate. A cognitive map is a collection of nodes linked by some arc. Then, Kosko (1986) came up with a new idea that combines fuzzy logic and cognitive maps called Fuzzy Cognitive Maps (FCMs). Meanwhile, Kandasamy & Smarandache (2003) proposed a new technique called Neutrosophic Cognitive Maps (NCMs) which is an extension of FCMs and indeterminacy is included. Therefore, it is easy and suitable to use FCMs and NCMs.

Since 2019, every human in this world is looking back to a new disease that has been spread across the globe called as coronavirus disease 2019 (COVID-19). This disease has created a big problem in the world, affecting people's lives and causing a large number of deaths. In late 2019, an unknown virus that related to severe acute respiratory syndrome (SARS) emerged in Wuhan, China. According to Elengoe (2020) the virus was named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). SARS-CoV-2 caused COVID-19 and expanded from Wuhan and was exported to almost all countries around the world. In March 2020, the World Health Organization (WHO) has been declared this virus as a pandemic. Reported illnesses