Safety Appraisal of Medical Personnel at Covid-19 Isolation Centres, Lagos State, Nigeria Using Fuzzy Logic

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Abstract The fatal Coronavirus disease 2019 (COVID-19) has continued to claim lives, in which, many of which have been frontline health workers. Thus a safety evaluation of the medical personnel is highly necessary in Lagos State isolation centres, Nigeria.One hundred and four (104) copies of the questionnaire were collected through telephone conversation from the medical personnel in four major Isolation Centres (ICs) in Lagos, Nigeria (i.e. ICs at Lagos University Teaching Hospital (LUTH), Lagos State University Teaching Hospital (LASUTH), Onikan, and Lekki). Safety assessment level was then carried out using a fuzzy logic approach, which is based on functions of four non-interactive input levels, i.e., LUTH 'I1' data (IC1), LASUTH 'I2' data (IC2), Onikan 'I3' data (IC3) and Lekki 'I4' data (IC4), which consist of its elements of safety, such as: not stick to preventive measures, lack of personal protective equipment, and contact with infected patients. The fuzzy output set is then defuzzified to arrive at a crisp (scalar) value. The fuzzy logic analysis showed that the total scores obtained for IC1, IC2, IC3, and IC4 were 7.721, 7.740, 7.150, and 7.060, respectively, corresponding to a crisp value of 7.50, which signifies the level of safety in thee centres. The fuzzy output crisp value, 7.50 of safety value for medical personnel in all the isolation centres fall in the class of good with a high membership value which revealed that occupational risk level was acceptable for medical personnel in all the four ICs in Lagos state.

Keywords COVID – 19, Safety analysis, Fuzzy logic, Isolation Centres, Medical Personnel, Defuzzified

1. Introduction

In Wuhan, China on 29 December 2019, the World Health Organization (WHO) used the term 2019 novel coronavirus to refer to a coronavirus that affected the lower respiratory tract of patients with pneumonia which began in Wuhan, China on December 8, 2019 [1]. The World Health Organization (WHO) announced that the official name of the 2019 novel coronavirus is Corona Virus Disease 2019 (COVID-19) [2]. These viruses are widespread in animals worldwide but have now been known to affect humans, previously known as 2019 – Novel Coronavirus [3]. Scientists immediately started to research the source of the new coronavirus, and the first genome of COVID-19 was published by the research team led by Prof. Yong-Zhen Zhang, on 10 January 2020 [4-5]. The disease has evolved and continues to be a very severe emergency across the globe. On March 11, 2020, WHO declared COVID-19 a pandemic, having met the epidemiological criteria of having infected > 100,000 people in at least 100 countries; however, on April 30, 2020, the world has confirmed over 3. 6 million cases and about 255,595 deaths [6] and has increased to 21 989 366, confirmed cases, 775 893 confirmed deaths and in 216 countries as at August 19, 2020 [7]. The Nigeria Federal Ministry of Health has confirmed a

coronavirus disease (COVID-19) case in Lagos State, Nigeria. The case, which was confirmed on the 27th of February 2020, is the first case to be reported in Nigeria since the beginning of the outbreak in China in January 2020 [8]. As of August 19th, 2020, 49,895 cases have been confirmed, 37044 cases have been discharged and 981 deaths have been recorded, and thus, increasing every day. In Lagos State only, 16, 920 cases have been confirmed, 14, 496 cases have been discharged and 201 deaths were also recorded, making Lagos the leading state in Nigeria [9].

The fatal virus has continued to claim lives, including the frontline health workers. However, there has been a rise in COVID-19 infections among medical personnel in the sub-Saharan region, especially in Nigeria. Many medical personnel have been infected while treating patients who were brought to the hospital with symptoms that later turned out to be COVID-19 [10]. According to Chikwe Ihekweazu (director-general of Nigeria Centre for Disease Control), the total number of medical personnel infected with the novel coronavirus in Nigeria had reached 812 as of June 2020 [11]. The chairman of the medical guild (Lagos Chapter), Dr. SodipoOluwajimi, also disclosed that as of May 2020, sixteen (16) medical personnel in the state's commercial hub have contracted the deadly coronavirus [4, 8], hence, the safety of medical personnel in Lagos State Isolation Centres (LSICs), regarding COVID-19, needs to be evaluated.

Safety is the state of being "safe" (from French Sauf), the condition of being protected against spiritual, financial, political, physical, social, emotional, occupational, psychological, educational or consequences of failure, accidents, damage, error, or any other event which could be considered non-desirable [12]. Safety is an action, or step timely taken to avoid the occurrence of detrimental effects on humans or equipment [13]. There are different techniques of assessing the safety status of medical personnel such as Monte Carlo, safety auditing among others, but those techniques are time-consuming and too much documentation process than fuzzy logic approach [14-15].

This project aimed at evaluating the safety of medical personnel in LSICs, in Nigeria using the Fuzzy logic approach.

2. Materials and Methods

To achieve the objectives of this research, medical personnel in four Isolation Centres (ICs) located in Lagos University Teaching Hospital (LUTH), Lagos State University Teaching Hospital (LASUTH), Onikan, and Lekki, were interviewed through questionnaire via phone conversations. Each questionnaire was structured into two (2) sections: section A; for demographics information, and section B; for assessment of each medical team prone to COVID-19 in the ICs, which served as a source of data for the fuzzy logic study. Subsequently, the responses were partitioned into homogeneous sub-groups to facilitate easy analysis. Data obtained from each isolation centre was analyzed by the use of Statistical Package for the Social Sciences (SPSS) software version 20.

2.1. Safety Status Assessment

The safety assessment in Lagos State Isolation Centres (LSICs), was carried by the use of fuzzy logic approach, which was based on the functions of four non-interactive input levels, i.e., LUTH 'I$_1$' data (IC$_1$), LASUTH 'I$_2$' data (IC$_2$), Onikan 'I$_3$' data (IC$_3$) and Lekki 'I$_4$' data (IC$_4$), and these four inputs consist of elements of safety. All factors upsetting safety in these LSICs were assessed from Section B of the questionnaire. Weight (W) was assigned to each element depending on the score getting from each element causing COVID-19, i.e. Not Stick to Preventive Measures (NSPM), Lack of Personal Protective Equipment (LPPE), and Contact with Infected Patients (CIP) while Rating Score (RS) was assigned to each element also depending on peak percentage score derived from the medical personnel in each IC.

Weighed Rate (WR) was then calculated as:

$$WR = W \times RS \tag{1}$$

While Score (S) was calculated as:

$$S = WR/10 \tag{2}$$

The scale of 0–10 was used to assess the status of these four inputs, the ranges of four input variables (IC$_1$, IC$_2$, IC$_3$, and IC$_4$) were considered and divided into three partitions or triangular fuzzy sets, these fuzzy sets are

designated with linguistic values of poor, good and excellent. The degree of belongingness of the values of a variable to any fuzzy class is called the degree of membership.

Figure 1 shows the range and classes of the mentioned inputs. The analysis of inputs and output data with a set of inference rules was based on IF-THEN statements. The fuzzy output set was then defuzzified to arrive at a crisp (scalar) value with the help of the centroid method, which signifies the level of safety in the ICs.
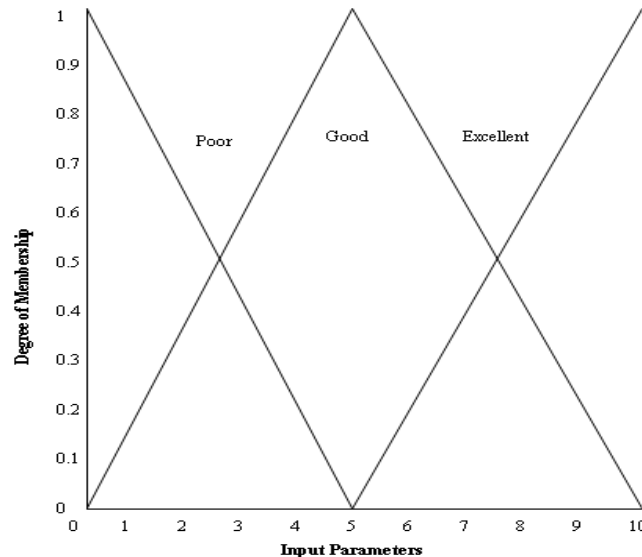

Figure 1: Range and Classes of Mentioned Inputs.
Source: (Rajat and Sanjoy, 2013.)

2.2. Categorized Fuzzy Sets Input

1. *Poor*: describes a system with no or poor evidence of safety measures, ranging from 0–10, the system with an overall score of less than 5.
2. *Good*: describes a system with good evidence of safety measures, ranging from 0–10, the system with an overall score of 4–8.
3. *Excellent*: describes a system with evidence of a very high level of safety measures, ranging from 0–10, the system with an overall score of more than 8.

2.3. Categorized Fuzzy Sets Output (Safety Status) (Figure 2)

1. *Very poor* signifies the high probability of occurring accidents with a fatality
2. *Poor* signifies the possibility of fatality, but high possibility of acute physical injury or harm, property damage
3. *Average* signifies the possibility of fatality and acute physical injury is virtually nil but possibility minor accidents and property damage remains high
4. *Good* signifies there is no possibility of fatality or serious accidents but a low possibility of minor injury and property damage
5. *Very good* signifies there is virtually no risk of accident of any kind.
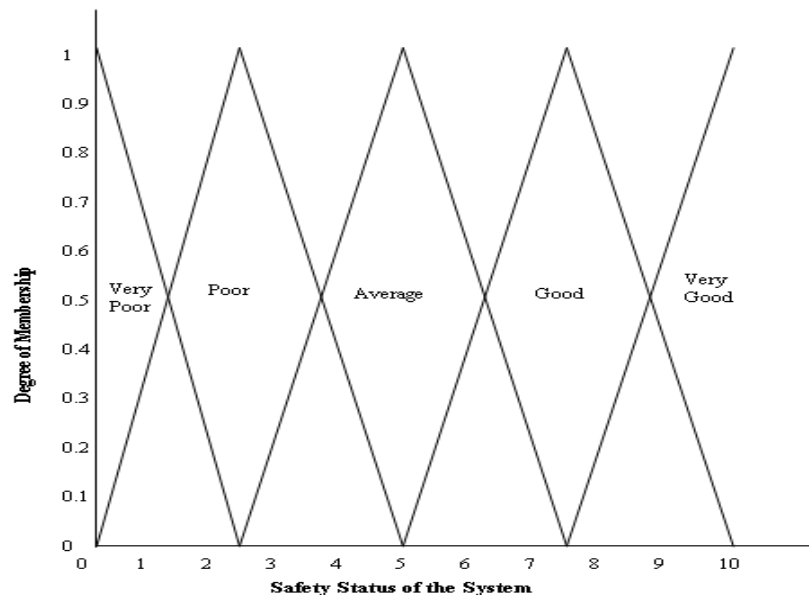
Figure 2: Fuzzification of the Safety Status (Output).
Source: (Rajat and Sanjoy, 2013.)

2.4. Inference Rules that Relate Input and Output Sets

1 IF IC_1 is poor and IC_2 is poor and IC_3 is poor and IC_4 is poor THEN Safety is very poor.

2. IF IC_1 is poor and IC_2 is poor and IC_3 is poor and IC_4 is good THEN Safety is poor.

3. IF IC_1 is poor and IC_2 is good and IC_3 is good and IC_4 is good THEN Safety is average.

4. IF IC_1 is good and IC_2 is good and IC_3 is good and IC_4 is good THEN Safety is good.

5. IF IC_1 is good and IC_2 is good and IC_3 is good and IC_4 is poor THEN Safety is good.

6. IF IC_1 is excellent and IC_2 is excellent and IC_3 is excellent and IC_4 is excellent THEN Safety is very good.

7. IF IC_1 is excellent and IC_2 is good and IC_3 is poor and IC_4 is good THEN Safety is good.

8. IF IC_1 is good and IC_2 is good and IC_3 is excellent and IC_4 is poor THEN Safety is good.

9. IF IC_1 is poor and IC_2 is excellent and IC_3 is good and IC_4 is poor THEN Safety is average.

10. IF IC_1 is excellent and IC_2 is excellent and IC_3 is good and IC_4 is poor THEN Safety is average.

11. IF IC_1 is excellent and IC_2 is good and IC_3 is good and IC_4 is excellent THEN Safety is good.

12. IF IC_1 is good and IC_2 is excellent and IC_3 is excellent and IC_4 is good THEN Safety is good.

3. Results and Discussion

One hundred and four (104) copies of questionnaires were administered to the medical teams at the Lagos state isolation centres, the respondents were drawn from the various isolation centres to ensure adequate and fair representation of views of medical teams on this subject. The rating score assigned to each element depends on the peak percentage score gotten from the analyzed data on each team as shown in Table 1. However, the numerical values for rate, weights, weighted rate, and score were determined for each safety element in IC_1, IC_2, IC_3, and IC_4 which was based on the relative significance of the elements causing harmful events as shown in Tables 2 to 5. It was revealed that 100% of the doctor pointed out that they were always using their PPE in the halls and premises of IC1 and IC4 (Tables 2 and 5), while, 80 % of the doctors in IC2 and IC3 pointed out they used their PPE when they were in isolation centre hall only (as shown in Tables 3 and 4 respectively). It was also noted that the highest weighted rate of 19.53, 20.46, 20.46, and 22.62, corresponded to securities of IC1 (Table 2), IC2 (Table 3), IC3 (Table 4), and IC4 (Table 5), respectively.For nurses, the least score of 0.00 was calculated for all the ICs., However, the input total scores of 7.721, 7.740, 7.150 and 7.060 were obtained for IC1, IC2, IC3, and IC4, respectively,which revealed that the input level of all isolation centres fall in the class of good (as shown in Table 2, 3, 4 and 5).

Table 1: Rating Score Assigned to each Element

Medical personnel	Options	Isolation centre I_1 (IC$_1$)		Isolation centre I_2 (IC$_2$)		Isolation centre I_3 (IC$_3$)		Isolation centre I_4 (1C$_4$)	
		Freq.	%(%)	Freq.	% (%)	Freq.	% (%)	Freq.	% (%)
Medical lab. scientists	LPPE	7	26.7	24	93.3	17	66.7	20	73.3
	NAPM	19	73.3	2	6.7	9	33.3	6	26.7
	CIP	0	0	0	0	0	0	0	0
Securities	LPPE	24	93.3	24	93.3	24	93.3	22	86.7
	NAPM	2	6.7	2	6.7	2	6.7	2	6.7
	CIP	0	0	0	0	0	0	2	6.7
Pharmacist	LPPE	19	73.3	21	80.0	12	46.7	19	73.3
	NAPM	7	26.7	5	20.0	10	40.0	7	26.7
	CIP	0	0	0	0	4	13.3	0	0
Record officers	LPPE	16	60.0	17	66.7	14	53.3	12	46.7
	NAPM	10	40.0	9	33.3	12	46.7	12	46.7
	CIP	0	0	0	0	0	0	2	6.7
Food technician	LPPE	19	73.3	14	53.3	15	60.0	12	46.7
	NAPM	5	20.0	8	33.3	8	33.3	10	40.0
	CIP	2	6.7	4	13.3	2	6.7	4	13.3
Health assistant	LPPE	24	93.3	24	93.3	24	93.3	22	86.7
	NAPM	2	6.7	2	6.7	2	6.7	4	13.3
	CIP	0	0	0	0	0	0	0	0
Nurses	LPPE	22	86.7	22	86.7	17	66.7	21	80
	NAPM	4	13.3	4	13.3	9	33.3	5	20
	CIP	0	0	0	0	0	0	0	0
Doctors	PPE	26	100	21	80	21	80	26	100
	NAPM	0	0	5	20	5	20	0	0
	CIP	0	0	0	0	0	0	0	0
Health attendants	LPPE	19	73.3	4	13.3	21	80	17	66.7
	NAPM	5	20.0	22	86.7	5	20	9	33.3
	CIP	2	6.7	0	0	0	0	0	0

Table 2: Results of Each Safety Element in Isolation Centre I_1 (IC1)

Elements of Occupational Safety (Medical Personnel)	Rate (approx. score)	Weight (Rate/total score)	Weighted Rate (Rate x weight)	Score (weighted rate/10)
Medical lab. Scientists	73	0.14	10.22	1.022
Securities	93	0.21	19.53	1.953
Pharmacist	73	0.07	5.11	0.511
Record officers	60	0.14	8.40	0.840
Food technician	73	0.21	15.33	1.533
Health assistant	93	0.07	6.51	0.651
Nurses	88	0.00	0.00	0.000
Doctors	100	0.07	7.00	0.700
Health attendants	73	0.07	5.11	0.511
TOTAL				7.721

Table 3: Results of Each Safety Element in Isolation Centre I_2 (IC_2)

Elements of Occupational Safety (Medical Personnel)	Rate (approx. score)	Weight (Rate/total score)	Weighted Rate (Rate x weight)	Score (weighted rate / 10)
Medical lab. Scientists	93	0.08	7.44	0.744
Securities	93	0.22	20.46	2.046
Pharmacist	80	0.08	6.40	0.640
Record officers	66	0.16	10.56	1.056
Food technician	53	0.22	11.66	1.166
Health assistant	93	0.08	7.44	0.744
Nurses	87	0.00	0.00	0.000
Doctors	88	0.08	7.04	0.704
Health attendants	80	0.08	6.40	0.640
TOTAL				7.740

Table 4: Results of Each Safety Element in Isolation Centre I_3 (IC_3)

Elements of Occupational Safety (Medical Personnel)	Rate (approx. score)	Weight (Rate/total score)	Weighted Rate (Rate X weight)	Score (weighted rate / 10)
Medical lab. Scientists	67	0.08	5.36	0.536
Securities	93	0.22	20.46	2.046
Pharmacist	47	0.08	3.76	0.376
Record officers	53	0.16	8.48	0.848
Food technician	60	0.22	13.20	1.320
Health assistant	93	0.08	7.44	0.744
Nurses	67	0.00	0.00	0.000
Doctors	80	0.08	6.40	0.640
Health attendants	80	0.08	6.40	0.640
TOTAL				7.150

Table 5: Results of Each Safety Element in Isolation Centre I_4 (IC_4)

Elements of Occupational Safety (Medical Personnel)	Rate (approx. score)	Weight (Rate/total score)	Weighted Rate (Rate X weight)	Score (weighted rate / 10)
Medical lab. Scientists	73	0.08	5.84	0.584
Securities	87	0.26	22.62	2.262
Pharmacist	73	0.08	5.84	0.584
Record officers	47	0.08	3.76	0.376
Food technician	47	0.26	12.22	1.222
Health assistant	87	0.08	6.96	0.696
Nurses	80	0.00	0.00	0.000
Doctors	100	0.08	8.00	0.800
Health attendants	67	0.08	5.36	0.536
TOTAL				7.060

The fuzzy output was defuzzified with the centroid method which returns the crisp value of the output as 7.50 , the value of safety at this COVID-19 isolation centre unit falls in the safety class of good with peak membership value, as shown in Plate 1
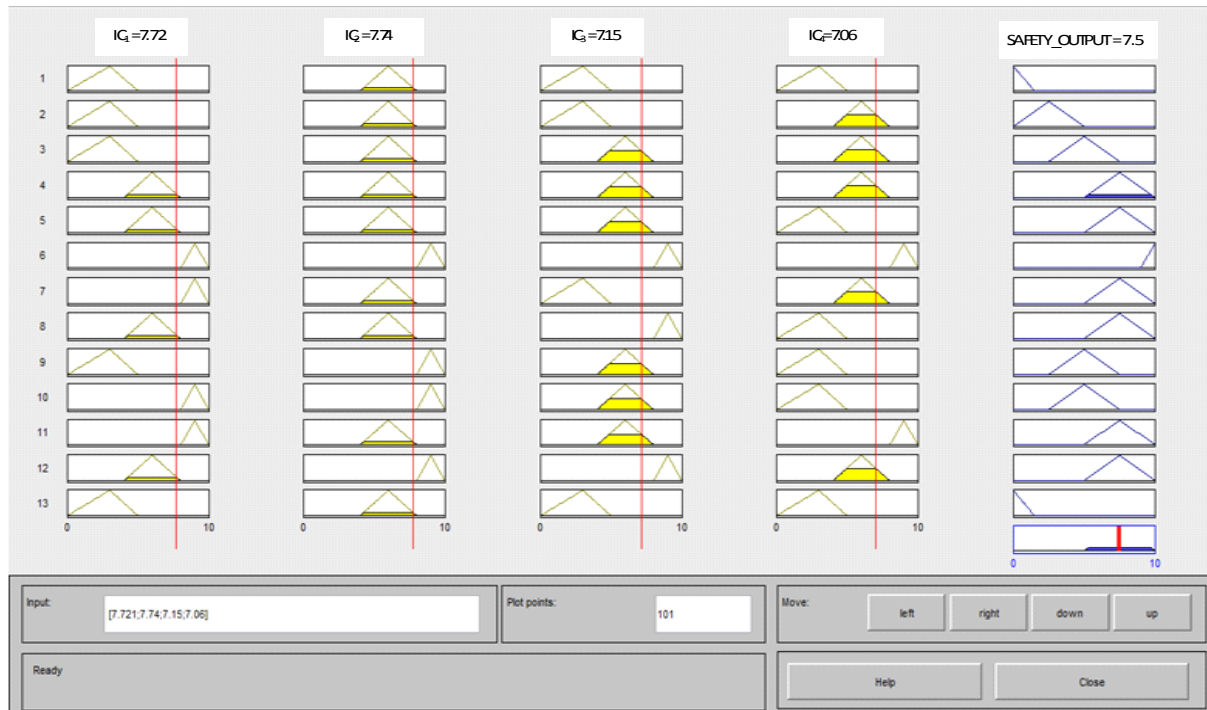

Plate 1: Aggregated Output of Occupational Safety Interface

4. Conclusions and Recommendations

Safety output total scores obtained for Isolation centre I_1 (IC_1), Isolation centre I_2 (IC_2), Isolation centre I_3 (IC_3), and Isolation centre I_4 (IC_4) were 7.721, 7.740, 7.150, and 7.060 respectively. The fuzzy output crisp value, 7.50 of safety at COVID-19 isolation centre unit falls in the class of *good* with high membership value, which describes high level of compliance with statuary safety regulations among medical personnel in Lagos state, Nigeria's isolation centres. The study further revealed that there is a low possibility of minor COVID-19 infection among the medical personnel which needs improvement. It was recommended that an online-based safety

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