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Fuzzy Logic Modeling of Covit-19 Mask and Social Distance

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Abstract

As a result of Covit-19 epidemics there are multiple vulnerabilities in a society. The COVID-19 outbreak has revealed multiple vulnerabilities in community systems. Inequalities may not only make containment challenging, but also result in infectious virus, which may cause to social distancing policies improper implementations in isolation from economic support mechanisms. It is necessary to address these vulnerabilities and provide local resilience improvements leading to sustainability integration by consideration of the basic requirements such as the social distance maintenance and musk wearing. The current study yields a fuzzy modeling inference system for mask wear and social distance variables effects on the disease based on some real and hypothetical data leading to potential disease uncertainty contents through membership degrees. This paper provides a fuzzy logic modeling to relate the social distance and musk wearing precautions to the epidemic ratio of the pandemic. A fuzzy inference system modeling is proposed to predict the impacts of mask wearing and social distance on the COVIT-19 disease possibility. The model digests uncertainties in all the input and output variables in a systematic manner for rational inferences.

Keywords: Covit-19, Distance, Fuzzy, Logic, Mask, Model, Social, Verbal

Introduction

The impact of COVID-19 pandemic has occurred in a multiple vulnerability manner on the societal activities and also gaps in many interconnected daily human affairs. It is, therefore, necessary to plan resilience and sustainability of these activities by taking into consideration precautions based on even the simplest modeling techniques that provide opportunity for planners and decision-makers. COVID-19 virus spread all over the world due to the international transportation, trade links, tourism activities, social daily affairs, gaps in the supply chains, etc.

The preliminary defense against COVIT-19 virus spread is the mask wearing and social distance maintenance provided that the hygiene is cared for. It is well-known that the social connectivity is one of the basic reasons for epidemic spread leading to pandemic problems, and therefore, the two most basic mitigation means are physical distance and mask wearing. Not only for mitigation, but also the necessary adaptation affairs are necessary to reduce the impact of pandemic. The COVID-19 outbreak gives a warning for possible present and future socio- economic disturbances, and therefore, the present case provides an opportunity for planning future events. Although there are many verbal recommendations and advices, their control is possible through fuzzy logic modeling principles, which subsume the qualitative information and knowledge sources in a systematic manner for rational and effective inferences.

In the literature, there are numerous papers about various aspects of the COVIT-19 epidemic features, but almost all of them are either in the verbal contents or probabilistic and statistical methodological approaches [1-4]. However, in this paper due to the vagueness, imprecision, incompleteness, in other words uncertainty components a verbal modeling is presented based on fuzzy logic principles and rules, which can be expanded in the future with inclusion of additional variables. In order to prevent the body from the epidemic danger of pandemy first depend on simple precautions such as mask wear and social physical distance in addition to the ventilation of the room wherever one enters. Additionally, avoidance of crowd supports the simple precautions.

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The COVID-19 has affected the health, economic, and social activities in an unprecedented manner concerning each individual to try and avoid its infectious influences.

During the COVID-19 pandemic people were advised to stay at home most of the time without complete public events and gatherings, which were canceled or delayed partially. This led to social contacts reductions significantly in open public spaces. In the social life person- to-person contacts are decreased in the society but allowed in households [5]. It is stated that the usage rate of face masks was high in public spaces (consistently > 90% during the time of lockdown) [6]. According to the World Health Organization recommendations the duration was shortened for detection and diagnosis of infected individuals, and consequently diagnosed individuals and those who were in close contact with them could be isolated in a timely manner [7, 8].

The face mask usage rate was chosen as 97.6%4 with 85% effectiveness during and after the national response against COVID-19 [9]. They indicated that social distance measures can reduce the average number of daily contacts by 80% in public spaces, but increase the contacts by two times in households [10].

Based on a dynamic compartmental model, this study aims to quantify the impact of social distancing on the transmission of COVID-19 in China in the presence of high coverage of face mask use [11].

Wearing masks are effectively implementable at a minimum cost without dramatically disrupting social practices, but its guidelines vary significantly among the countries. Unrespectable of any condition more regions recommend or mandates to wear masks in public. The study by Li et al combines mathematical modeling and existing scientific evidence to evaluate the potential impact of the utilization of normal medical masks in public to combat the COVID-19 pandemic [12]. The position of mask on the face and the social distance reduce the transmission potentiality. In this paper the fuzzy logic inference system is employed to determine the impact of mask and social distance factors on the virus reduction and infection attack rate in a general population. The mask wearing and social distance factors are exemplified by means of fuzzy sets, hence the impacts of mask-wearing and simultaneously caring for the social distance on the epidemic relationship with increasing awareness and availability. In general, mask wearing can be combined effectively with social distancing to subsidize the epidemic curve. The fuzzy inference system as presented in this research helps to provide a projection based only on currently available verbal data without numerical records and hence, the disease potential can be estimated. The proposed fuzzy inference system model in this paper provides a basis for further modeling alternatives in the case of numerical data absence.

Feng et al. stated that in the East Asian countries, especially, in China and South Korea, mask wear management is very effective to reduce the epidemic rate to the minimum [13]. In previous studies the quality and complete mask wearing are taken into consideration, but in this work a digression is taken as the “loose”, “half” and “complete” mask wearing possibilities. In this work also, the WHO’s recommendations are taken into consideration [8]. It is assumed that the masks are available for whole the population. A detailed account of fuzzy inference system modeling principles is explained extensively in a book by Şen [13].

As for the mask wear there are advantages such as the in general, viral transmission prevention in the general population, because mask impacts turbulent gas cloud formation [14]. On the other hand, the mask material filters viral particles such as aerosols and droplets [15]. The mask wear reduces potentially the risk of infecting other people when the exact individual wears a mask for protection.

The personal social activities, communications and contacts among people make them vulnerable to various natural and man-made non-comforts such as the infectious diseases. Sharifi et al. showed that the impacts of COVID-19 on cities is mainly related to four major themes, namely, (1) environmental quality, (2) socio-economic impacts, (3) management and governance, and (4) transportation and urban design [16]. The issues of socio- economic impacts and management and governance are considered in this article for individual social activity behaviors by means of mask wearing and social distance non-record modeling through fuzzy logic principles. In the literature there are medical issues related to the diagnosis and treatment of the disease [17].

Among the preliminary preventive measures against COVIT-19 disease are inadequate social distancing and quarantine measures in addition to mask wearing types [18]. There are various inequality issues especially within a crowd society to keep away the infectious spread of and viral occurrence, and hence, such inequality issues make it difficult to socially distance, thereby undermining the effectiveness of ‘homestay’ orders for containing the spread of the virus [19]. Similar issues have also been discussed in the context of some African and Brazilian cities [20, 21]. Conditions in slums and informal developments are further exacerbated by the lack of access to medical care (e.g., hospital beds) and basic services such as clean water to comply with hand washing recommendations [21, 22]. Additionally, many communities depend on close social interactions for their livelihood make adherence to ‘stay home’ orders challenging [13, 20].

The percentage of mask wearing people varies from society to other by taking into consideration different thoughts. For instance, the culture of the society plays significant role in mask coverage percentage. Herein, coverage means either “incomplete”, “half” or “complete” coverages, which are among the main topics of this article. Apart from the COVIT- 19 people wear masks due to various causes including allergies, cold protection and pollution.

It is obvious from the previous studies that across five countries there is a significant gap between 71% and 8% as for the mask wear [23].

Billions of people have been blocked at homes worldwide, because of the dangerously contagious virus, COVID-19. As preliminary precautions mask wear, social distance and hygiene are recommended daily to avoid the spread of the virus. These precautions help to control the contiguous disease until a full cure becomes available. As for the mask, social distance and hygiene variables they are not measurable, but recommended verbally, and therefore, this paper provides a fuzzy logic inference system to search for logical causative relationship of mask wear and social distance on the disease level. The research is focused on finding a suitable fuzzy logic rule base propositions that can model the COVID-19 daily verbal information about the variables considered. It is the main purpose of this article to provide the simplest fuzzy logic modeling based on the must wear and physical distance maintenance as input variable to predict the output variable of the rate of epidemics.

Fuzzy Modeling Bases

In the literature there are mathematical models in terms of probability and statistical methodologies to assess the COVIT-19 numerical data sources [24]. It is possible to make probabilistic and statistical modeling provided that there are past data records, which are available numerically even on daily basis [25-27]. Such numerical modeling techniques do not take into consideration the basic logical and rational connectiveness among the variables concerned.

Figure 1: Overall structure of modeling

As for the mask usage there are three alternatives to sure it covers the nose, mouth and chin, which is the "perfect" coverage. If the upper rim of the mask is on the chin then it is "imperfect" coverage. If the rim is next to the nose the coverage is referred to as "half". Each one of these words is vague, which are the actual situation in the daily social life. Furthermore, Masks are among the comprehensive measures to suppress COVID-19 transmission to save lives. However, only its use is not enough for adequate protection against the pandemy. It is recommended that Masks should completely cover the nose and mouth.
Another important factor is the distance from other individuals. Logically, the nearer one is to someone who has infection, the greater is the virus risk catching. On this issue the World Health Organization recommends keeping a distance of at least 1m. Of course, the distance keeping should be effective simultaneously by mask wearing. Even though the recommendation is 1 m, but in social life the infection is inversely proportional with the distance. The more is the distance the less is the spreading of virus. Since, there are no measurements about the distances, it remains quite a vague concept, and therefore its fuzzy logic modeling comes into view. For this purpose, the distance is expresses by three fuzzy words as "close", "medium" and "far".

Finally, the output variable disease can be represented also by three fuzzy words as "low", "moderate" and "high" risk categories.

After having explained the fuzzy logical relationships between the position of the mask and distance with respect to epidemical spread, it is now possible to represent them in the forms of fuzzy sets. The core of the fuzzy modeling is to write down the expert verbal relationships among all the fuzzy words, which is given in Table 1.

Table 1: Verbal relationships among the input and output variables

Distance	Mask		
	"Imperfect"	"half"	"Perfect"
"Close"	"Moderate"	"Moderate"	"High"
"Medium"	"Moderate"	"Moderate"	"High"
"Far"	"Low"	"Low"	"Low"

This following window includes nine possible relationships among the three variables and their fuzzy logical rules set. All the aforementioned relationships among the three variables are hidden in these fuzzy logic rules. It is obvious that the input variables are connected to each other by AND conjunctive. Since either anyone of the rules is valid at one instant, they are related to each other by OR conjunctive.

Rule 1: **IF** Mask is "Imperfect"	**AND** Distance is "Close" **OR**	**THEN** disease is "Low"
Rule 2: **IF** Mask is "Imperfect"	**AND** Distance is "Medium" **OR**	**THEN** disease is "Moderate"
Rule 3: **IF** Mask is "Imperfect"	**AND** Distance is "Far" **OR**	**THEN** disease is "Moderate"
Rule 4: **IF** Mask is "Half"	**AND** Distance is "Close" **OR**	**THEN** disease is "High"
Rule 5: **IF** Mask is "Half"	**AND** Distance is "Medium"	**THEN** disease is "High"
Rule 6: **IF** Mask is "Half"	**AND** Distance is "Far" **OR**	**THEN** disease is "Moderate"
Rule 7: **IF** Mask is "Perfect"	**AND** Distance is "Close" **OR**	**THEN** disease is "Moderate"
Rule 8: **IF** Mask is "Perfect"	**AND** Distance is "Medium" **OM**	**THEN** disease is "Moderate"
Rule 9: **IF** Mask is "Perfect"	**AND** Distance is "Far"	**THEN** disease is "Low"

Application

The application of the fuzzy logical modeling principles explained in the previous section can be achieved in the computers, but the verbal information needs to be concerned into computer understandable forms. At this junction, the fuzzy sets enter into the scene, which are adapted in this paper as triangular fuzzy sets, which can be changed to other types later, if necessary. Figure 2 shows the fuzzy set expressions for the computer communication.

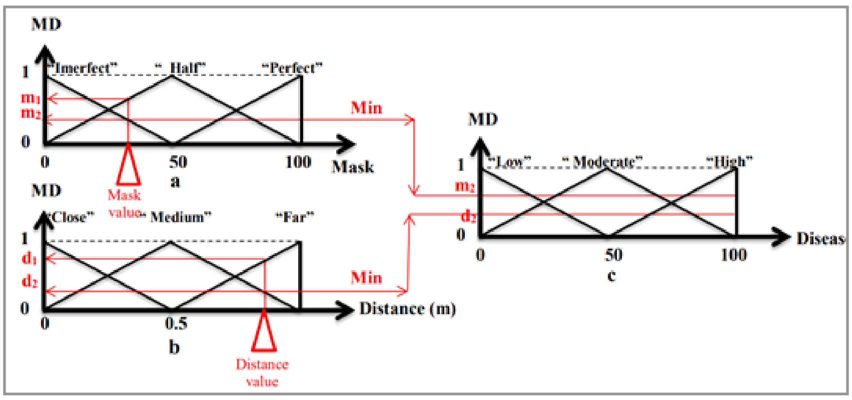

Figure 2: fuzzy sets a) Mask, b) Distance, c) Disease

For instance, according to the illustrative example in Figure 2 mask (distance) fuzzy data triggers two fuzzy sets "perfect" and half" ("medium" and "far") with MDs m1 and m2 (d1 and d2), which corresponds to fuzzy rules in the above window to Rule 2, Rule 3, Rule 5 and Rule 6. In order to explain the fuzzy model in more explicitly these rules are drawn collectively in Figure 3.

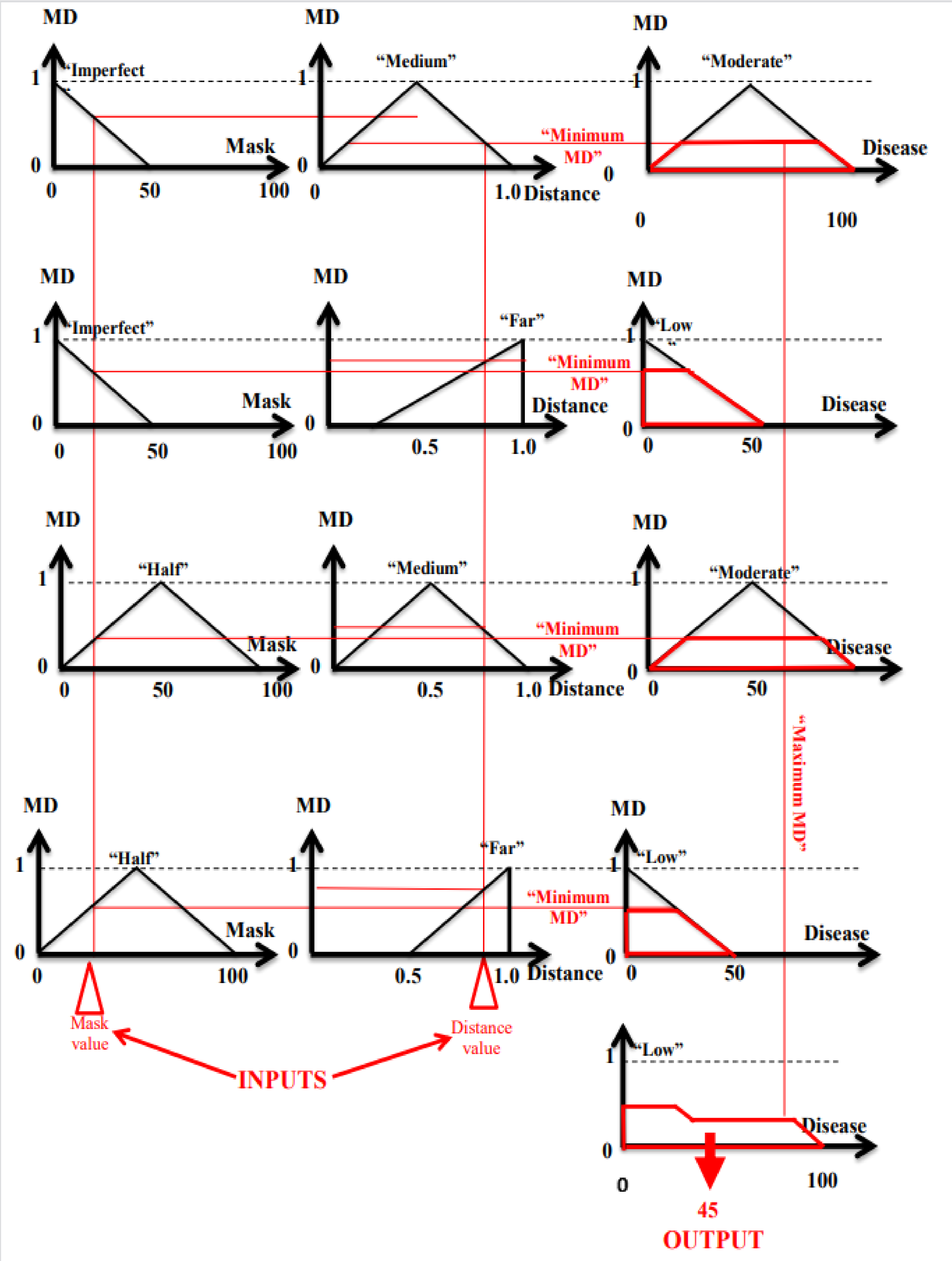

Table 2: Hypothetical mask and distance values

Mask (%)	Distance (m)	Mask MD	Distance MD	Minimization	Rule triggering	Disease
100	0.5	0.9802	0.0000	0.0000	8	50.0
90	1.0	0.7822	0.9802	0.7822	9	20.3
80	0.3	0.5842	0.4059	0.4059	4, 5, 7, 8	54.9
70	0.4	0.3861	0.2079	0.2079	4, 5, 7,8	61.0
60	0.8	0.1881	0.5842	0.1881	5, 6, 8, 9	51.5
50	0.7	0.0099	0.3861	0.0099	5, 6	61.0
40	0.6	0.2079	0.1881	0.1881	2, 3, 5, 6	70.0
30	0.2	0.4059	0.396	0.3960	1, 2, 4, 5	53.1
20	0.9	0.396	0.7822	0.3960	3, 6	50.5
10	0.1	0.1980	0.1980	0.1980	1	21.4

After the minimization of the mask and distance variables according to the hypothetical values in Table 1 The type of triggered output fuzzy sets are shown in the fourth column of this table and the maximization procedure among the output fuzzy sets are also presented in the column five. It is obvious that not all the nine fuzzy rules in the above window are triggered simultaneously. The maximum number of rule triggering is four as representatively shown in Figure 3. In the fifth column of Table 1, the number of fuzzy rules is shown as corresponding to the hypothetical mask and distance numerical values. The final output values for disease are given in the sixth column. In the fuzzy inference system, the defuzzification is achieved as centroid method, and therefore it is not possible to expect the result to have completely certain 100% or completely uncertain 0% cases. The model results vary between these two extremes without significant closeness to either of the two.

After all what have been modelled and explained in the previous text the mask and distance observance does not guarantee the infectious effect of COVIT-19. However, mask and distance preserve according to the recommended standards certainly help to reduce COVIT-19 danger to a certain extent.

Conclusion

CVOVIT-19 has affected many social, economic, commercial, environmental and industrial affairs for few years in every corner of the world. There are numerical values concerning various aspects of the death tolls, curement, disease, heavily illness numbers, which provide probabilistic, statistical, stochastic and Monte Carlo methodological applications, because all of the requires numerical data. On the other hand, there are some preliminary protective measures that cannot be controlled by numerical quantification, but verbal adjective words and rational sentences play the dominant role. Especially, recommendations of mask wearing and social distance protection are not applied completely by the social societies, and therefore, there are verbal vague, incomplete, missing, imperfect, insufficient ingredients, which are without numerical quantitative measurements but verbal recommendations. Verbal information and precautions are prone to be modeled only by fuzzy logic principles and inference systems. It is the main purpose of this paper to present a two-input-one-output fuzzy logic modeling by consideration of mask wean and social distance as input variables and disease degree as output variable. For this purpose, mask and distance variables are fuzzified by three fuzzy sets as "Imperfect", "Half" and "Perfect" and "Close, "Medium" and "Far" sub- verbs, respectively. The output variable fuzzy sets are "Low", "Half" and Medium". The fuzzy rule sets are presented by a set of fuzzy of IF…. THEN…. statements with their explicit forms. In the modeling procedure, the membership degrees (MDs) for each fuzzy set are adapted as triangular membership functions. There are 9 fuzzy sets, which are related to output fuzzy sets. The execution is achieved by Mamdani fuzzy inference modeling technique. Since, there are no recorded data practically for the mask and social distance variables a set of hypothetical values are selected such as to cover all possible alternatives that may be encountered in everyday life. It is observed that the most frequently encountered diseases causative result appears as "Moderate". This is to say that mask and social distance do not avoid the epidemic completely even though they are applied systematically. However, their common activity helps to reduce the disease to a significant extent.

Finally, it is observed through the fuzzy logic modeling inference system that mask and distance cannot prevent COVIT-19 infectious effects completely, and according to the study in this paper the maximum protection percentage is around 70%. The model basis in this paper can be expanded to include injection percentage, hygiene and other verbal variables related to the subject.

Ethics Declaration

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards

Conflicts of Interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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